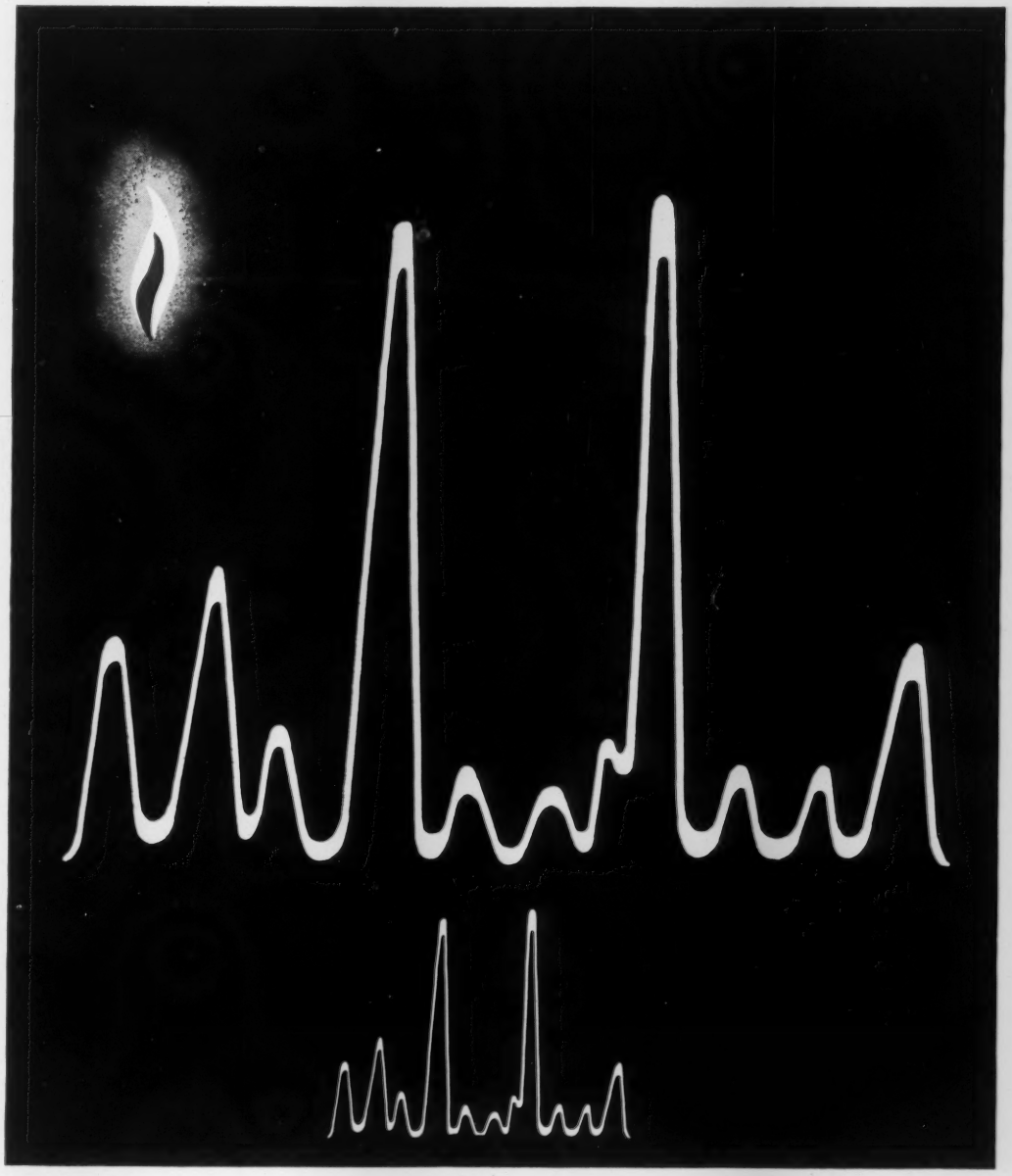
INSTRUMENTS AND CONTROL SYSTEMS

NOVEMBER 1961 JOURNAL OF THE SCMA • PRECISION MEASUREMENTS ASSOCIATION • SIMULATION COUNCIL NEWSLETTER



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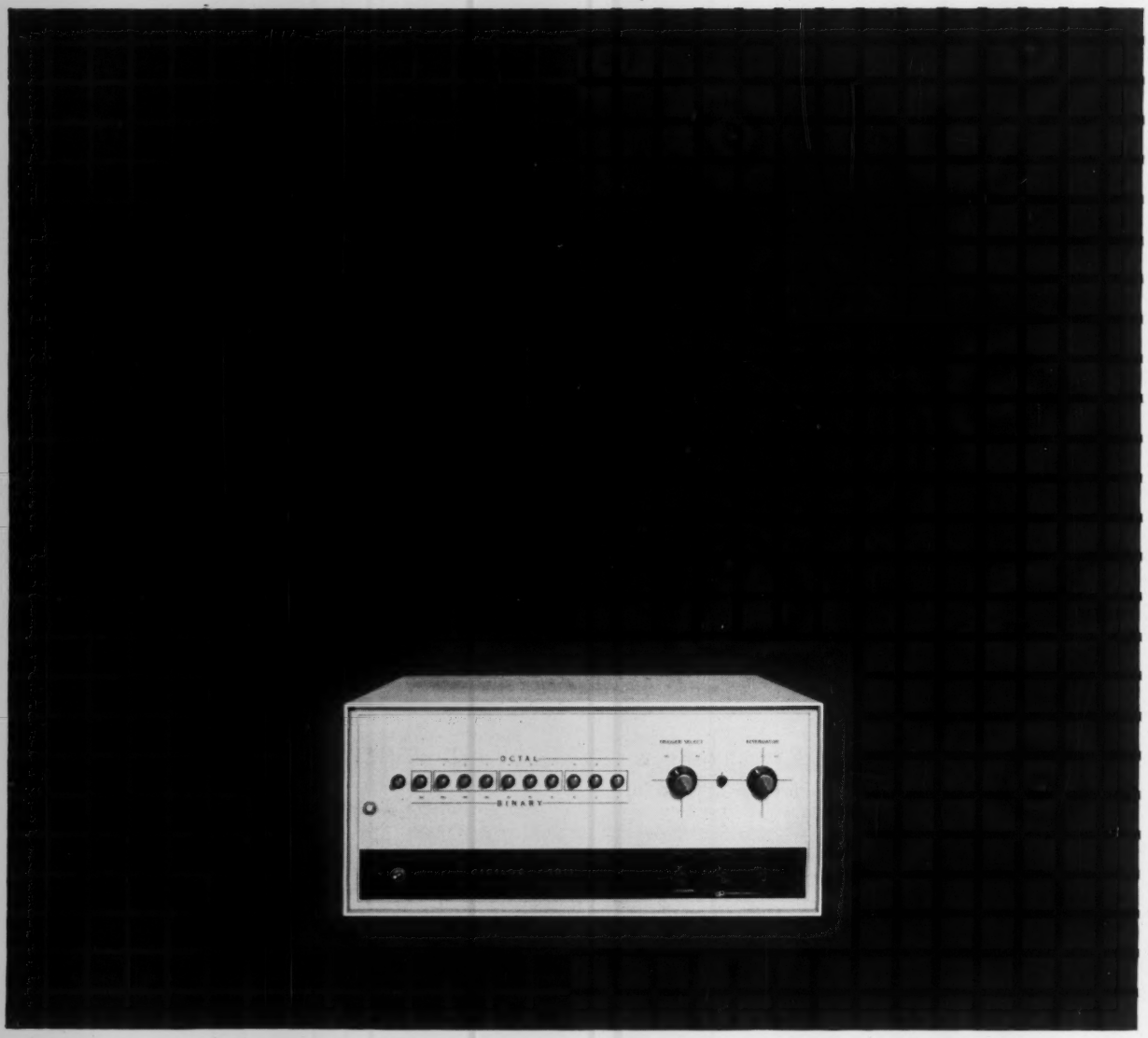
Differential Measurements 2078



INTRODUCING LIBRASCOPE'S ELECTRONIC DIGILOG*-1011 FOR VOLTAGE-TO-DIGITAL/DIGITAL-TO-VOLTAGE CONVERSIONS

Use it as a precision input unit with computers, data loggers, storage units and other instrumentation. Use it wherever conversions must be fast and accurate. For the DIGILOG-1011 performs up to 5,000 voltage-to-digital conversions per second, 100,000 digital-to-voltage per second. Digital output is 10 bits plus sign in binary and octal code, and may be serial or parallel. DIGILOG-1011's low-density component packaging results in solid-state circuitry offering exceptional reliability and life expectancy, and low initial cost. DIGILOG-1011 accepts inputs in these full-scale ranges: ±1.023v, ±10.23v, ±102.3v. Accuracy is ±0.03% ±½ bit, and stability is ±0.03%. Input resolution: 1 mv minimum. *For technical details on the* DIGILOG-1011, *write or call Librascope today.*

*TRADEMARK, GENERAL PRECISION, INC.

GENERAL PRECISION

LIBRASCOPE DIVISION | GENERAL PRECISION INC., GLENDALE 1, CALIFORNIA

CIRCLE 1 ON READER-SERVICE CARD

LEWIS

RESISTANCE THERMOMETER AND ACCESSORIES

The Model 62 RT4F Resistance Thermometer is a sturdy, easy to read instrument with a six inch hand drawn scale. It is suitable for use in moving vehicles, is excellent for flight testing or for permanent panel installations. Operated by an ordinary dry cell and calibrated to standard "AN" bulb curves, this instrument is ideal for use with any of the resistance bulbs illustrated below. Other ranges available in °C or °F.

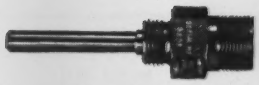
ACCESSORIES — RESISTANCE BULBS AND SWITCHES

Lewis Selector Switches have been used for years in automotive test work as well as in permanent installations. Simple, sturdy construction plus finest materials combine to give long service.

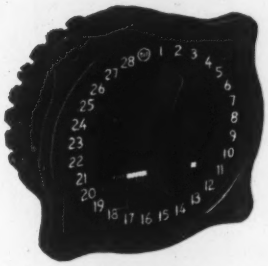
2" SIZE TO 4 POINTS

FREE AIR

3" SIZE TO 20 POINTS



THREADED "AN" TYPE



4" SIZE TO 28 POINTS

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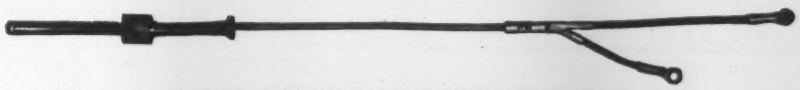


BAYONET TYPE FOR CYLINDER HEAD TEMPERATURE

Lewis Resistance Bulbs are adaptable for use with the 62RT4F Resistance Thermometer or with standard aircraft panel indicators. Special purpose bulbs with stem variations or for high temperature applications are available.

We invite inquiries on your temperature measuring problems.

THE LEWIS ENGINEERING CO.

Manufacturers of *Complete* Temperature Measuring Systems for Aircraft

NAUGATUCK, CONNECTICUT

CIRCLE 2 ON READER-SERVICE CARD

SENSITIVE RESEARCH

A NEW AC VOLTAGE STANDARD

■ .01%* Accurate AC/DC Difference Measurements

■ .013% Accurate Absolute AC Voltage Measurements

■ Full Accuracy Over Entire Frequency Range from 20 cps—50,000 cps

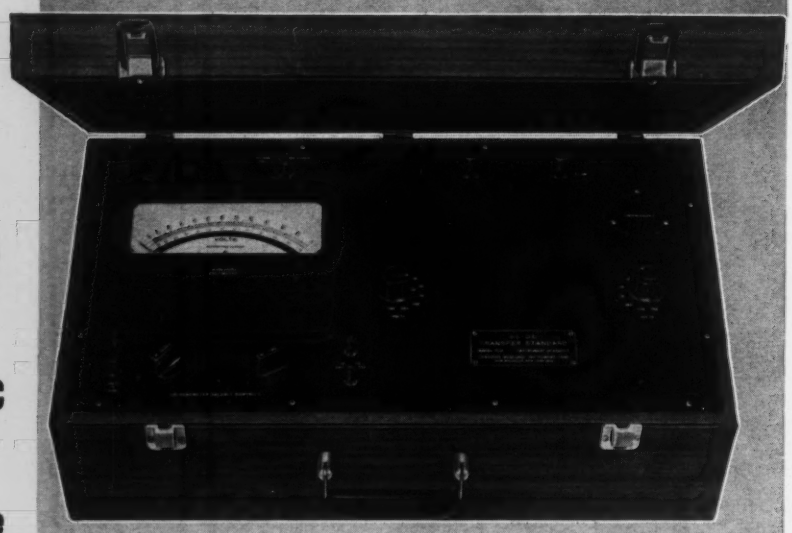
■ True RMS Response

FREQUENCY CORRECTIONS IN % OF READING
MODEL FLH

VOLTS	20 Kc	30 Kc	50 Kc
1.5-4.5	0	0	+.01
above 4.5-11.25	0	0	0
above 11.25-22.5	0	0	0
above 22.5-45	0	0	—.012
above 45-112.5	0	0	—.015
above 112.5-225	0	0	0
above 225-450	0	0	—.026
above 450-1125	—.027	—.038	—.069

**It is the present policy of NBS to state their maximum measuring uncertainty as ±.02%. However, they are expected to reduce this possible error to ±.01% in the near future, and the instrument is guaranteed on this basis. It is also their present practice to limit testing to 30 kc on instruments of the Model FLH's accuracy unless the user is in a position to justify that certification to 50 kc or higher is imperative. Correspondence between NBS and the user is required in such an instance.*

The Model FLH has been named in honor of Francis L. Hermach of the National Bureau of Standards in Washington, D. C., in recognition of his accomplishments in the field of AC/DC transfer measurements.



MODEL FLH

The Model FLH is a *NEW* thermocouple transfer standard designed to measure directly in percentage of reading, the influence of frequencies between 20 cps — 50,000 cps on the indication of voltmeters, calibrators, and other transfer standards over a range of 1.5 — 1125 v. It is supplied with an NBS Certificate* showing correction figures for those values of voltage where the AC/DC difference (or frequency influence) is, or exceeds, ±.01%. Typical performance characteristics are listed in the table on the left. These figures illustrate that it is seldom necessary to apply corrections to achieve substantially better performance than is basically guaranteed. Since the highest volt ranges have the greatest frequency influence, in practical usage the lower volt ranges can be considered to have either greater fundamental accuracy or a frequency span well beyond 50 kc.

The Model FLH when employed in conjunction with precision DC potentiometers and their accessories, is ideally suited for use in the certification of other AC voltage standards and the making of extraordinarily high accuracy absolute AC measurements. **An AC system accuracy of ±.013% can be obtained without difficulty** by combining the FLH with Sensitive Research "COMMANDER" instruments such as the Dauphinee DC Potentiometer, Type 9144 (accuracy ±.001%), the NBS Volt Ratio Box, Type 9700A (accuracy ±.001%) and Saturated Standard Cells, Type 4305 and Constant Temperature Enclosure, Type 9152 (accuracy ±.001%). A "COMMANDER" Instrument Catalog is available upon request.

The basic accuracy of the Model FLH is derived from the flat frequency response of its multipliers. Long term resistor stability is of no importance. If the instrument is not physically impaired its frequency response will remain fixed indefinitely.

Replacement thermocouples are of the uncalibrated type.

ADDITIONAL SPECIFICATIONS

Accuracy using NBS correction figures: ±.01% of reading from 20 cps — 50 kc.*
Accuracy without using correction figures: ±.01% of reading to 30 kc from 1.5—450 v; ±.03% to 50 kc; ±.05% of reading to 30 kc from 450—1125 v; ±.075% to 50 kc.
Resolution: ..... ±.005% minimum.
Price: ..... $1685.00 (includes NBS Certificate and Type SR4 Galvanometer).
Terms: ..... Net 30 days, f.o.b. NBS, Washington, D. C.

Write for additional information or contact your nearest SRIC sales representative.

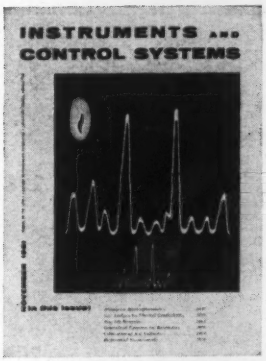
Symbol of Quality

SENSITIVE RESEARCH INSTRUMENT CORPORATION
NEW ROCHELLE, N. Y.

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

CIRCLE 3 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS



Rays of radiation emphasize the beginning of another exciting I&CS series—on analytical techniques, the subject of major emphasis this month

VOLUME 34, NUMBER 11, NOVEMBER 1961

PRINT ORDER THIS MONTH 45,250

EDITORIAL

The Awesome Servants 2043

FEATURE ARTICLES

Absorption Spectrophotometry 2049

RAY SAWYER—discusses principles of infrared spectrophotometry and the basic types of spectrophotometers. This begins another I&CS series—on analytical techniques.

Gas Analysis by Thermal Conductivity 2055

JAMES L. McFADDEN—An accurate, simple and fast technique for measuring or monitoring the composition of a mixture of gases.

Applications of Process Stream Analyzers 2059

DAVID J. FRAADE—Typical applications, including plant and service.

Disc File Memories 2063

HAROLD J. McLAUGHLIN—Discusses serial and parallel operation, selective alteration, interlacing, etc. This is number 9 in our series on data storage.

A Generalized Equation for Rotameters with Spherical Floats 2070

ROGER GILMONT and PAUL W. MAURER—A simplified generalized equation is developed by using terminal velocity via Stoke's Law.

Analysis of Water in Jet Fuels 2074

MICHAEL CZUHA and KENNETH W. GARDINER—Dissolved water, suspended water, and total water are each indicated in parts per million continuously

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INSTRUMENTS AND CONTROL SYSTEMS

VOL. 34 NO. 11
NOVEMBER 1961

Differential Measurements 2078

V. B. KWAST—Three basic techniques for differential measurements. This is this month's selection of the Precision Measurements Association.

Gage-Block Interferometer 2085

An NBS development

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION 2086

CAVITATION IN CONTROL VALVES by G. F. STILES—Here is how to design the risk out of cavitation—which no known material can withstand.

SIMULATION COUNCIL NEWSLETTER 2095

Western S/C Meeting of 12 May on "The Future of Analog Computation" 2095

Western S/C Meeting of 14 Sept. on Use of Computers at Autonetics 2097

Analog Techniques—Automatic Scale Changer 2102

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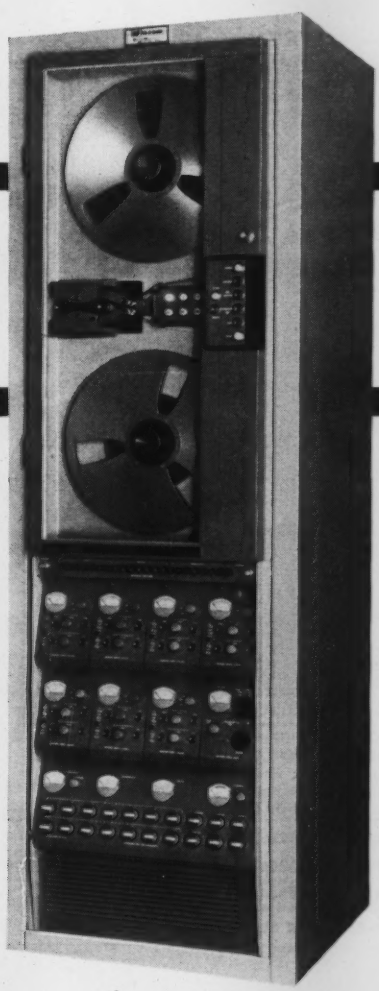
Now Mincom offers the industry extended bandwidth and improved predetection recording...the MINCOM Series CM-100 Instrumentation Recorder/Reproducer

At 120 ips the Mincom Series CM-100 now delivers 1.5 mc*—and also makes possible predetection recording/reproducing with dropouts virtually reduced to zero. This superb improvement in predetection performance is accomplished by redundant data recording. The two carrier tracks are fed through a new and exclusive Tracklok® to eliminate skew, and thence as a single track into a demodulator to recover the original information. It's well worth seeing, especially if you need reliable operational predetection at your facility—and need it in FM/FM modulation, PCM and PCM/FM.

*Optional

1.5 megacycles* ...at 120 ips



MINCOM SERIES CM-100

Frequency response of 1.5 mc is obtained in the single-rack CM-100. A second auxiliary rack houses a demodulator, an oscilloscope monitor unit, and Mincom's new and exclusive Tracklok.

Mincom Division 3M MINNESOTA MINING & MANUFACTURING CO.

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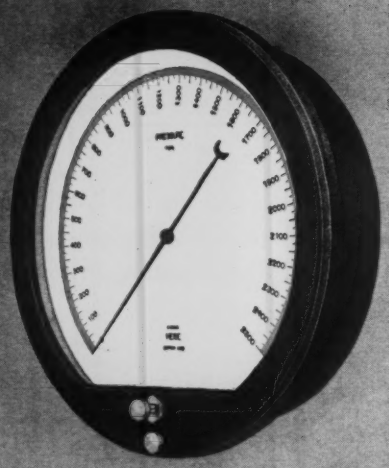
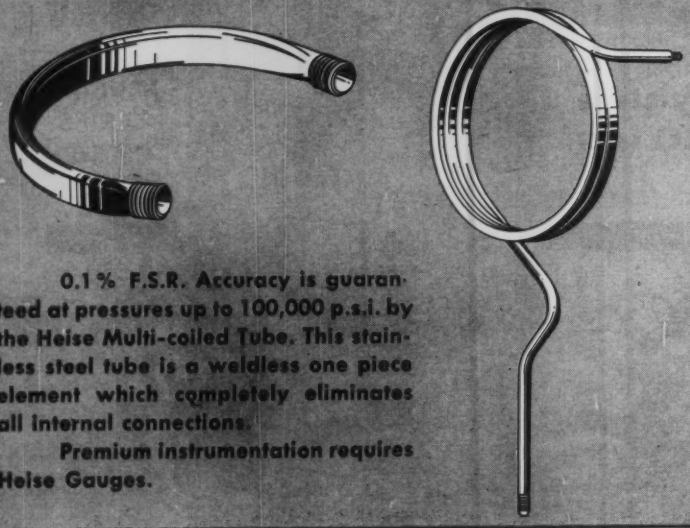
HEISE GAUGES

Corrosion Resistance

IN ULTRA HIGH PRESSURE INSTRUMENTS

Modern laboratory applications frequently require resistance to corrosive and semi-corrosive fluids as well as peak performance in ultra high pressure ranges. Heat treated 403 Stainless Steel, in an exclusive weldless Bourdon tube, provides superior service under the most critical conditions. Heise Gauges are frequently specified for use with mercury as a pressure medium.





0.1% F.S.R. Accuracy is guaranteed at pressures up to 100,000 p.s.i. by the Heise Multi-coiled Tube. This stainless steel tube is a weldless one piece element which completely eliminates all internal connections.

Premium instrumentation requires Heise Gauges.

Dial Sizes	FULL SCALE READING (P.S.I.)						
	0-15 to 0-5,000 inclusive	Over 0-5,000 and including 0-20,000	Over 0-20,000 and including 0-30,000	0 to 40,000	0 to 50,000	0 to 75,000	0 to 100,000
8½"	$183.50	$205.50	$238.50				
12"	$209.50	$231.50	$264.50	$275.50	$286.50	$336.50	$386.50
16"	$255.50	$277.50	$310.50	$321.50	$332.50	$382.50	$432.50

DELIVERY — 2 WEEKS FOR MOST RANGES — PRICE F.O.B. NEWTOWN

Request Catalog for SPECIAL FEATURES

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BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 5 ON READER-SERVICE CARD

I&CS NEWS

Computer Controls Refinery

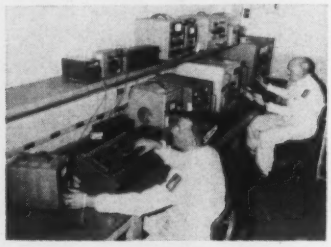
LOS ANGELES, CALIF.—TRW Computers Company, a division of Thompson Ramo Wooldridge Inc.,* has installed an RW-300 computer control system at the Tulsa refinery of DX Sunray Oil Company to perform on-line, closed-loop control of a new 85,000 barrel-per-day crude oil distillation unit. The new distillation unit, which replaces five older crude units that had combined capacity of 75,000 barrels per day, is the "first major refinery unit to incorporate a computer control system in its original design." It went on stream in mid-September. The RW-300 scans 191 process instruments and adjusts 30 controller setpoints to maintain optimum efficiency.

*8433 Fallbrook Ave., Canoga Park, Calif.

CIRCLE 182 ON READER-SERVICE CARD

Calibration System

PHILADELPHIA, PA.—"Overall Air Force Integrated Calibration System," at Olmsted Air Force Base, Middletown, Pa., uses five air-conditioned tractor-trailers to service

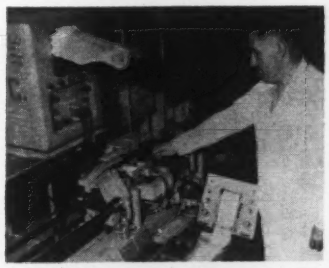


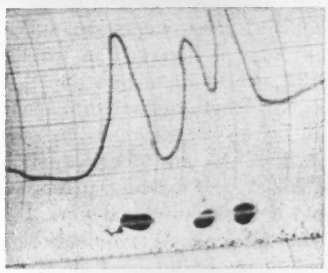
major bases including radar equipment at the "Texas Towers" off the Atlantic coast. These mobile laboratories contain more than $100,000 worth of instruments among them many precision potentiometer, bridges, etc. More than 100 different types of calibrations can be made.

ASA, the American Standards Association, upon recommendation of the ISA, is undertaking a study to standardize identification of pneumatic tubing for control panels.

Nuclear Fuel Elements Tested

CLEVELAND, OHIO—A rapid method to prevent scrapping of costly nuclear fuel elements uses ultrasonics for nondestructive tests. The method was developed by Atomic Power Development Associates





(APDA) and Power Reactor Development Company (PRDC) for the inspection of core A fuel elements. (14,000 pins were used in the new Enrico Fermi fast-breeder reactor for the first core loadings.) The length of every unit is scanned during inspection and results are recorded on a Mark II direct-writing recorder (Brush Instruments Division of Clevite Corp., 37th & Perkins, Cleveland 14, Ohio). Similar tests for elements of the radial and the axial type use eddy-current methods and recorders to obtain a permanent record of the element. Minute cladding surface flaws show up as well as internal defects in core and clad.

Chart indicates deflections which were air pockets trapped in the sodium. An eddy-current type instrument was used for detection.

CIRCLE 183 ON READER-SERVICE CARD

AMERICAN ASSOCIATION FOR CONTAMINATION CONTROL

(450 W. Fort St., Detroit 26, Mich.) has been formed for "persons having a professional interest in the design, operation, supervision, or supply of equipment for contamination controlled areas." James Mildon, of Lear, Inc. is president, Eugene Sloane, of Air Engineering is secretary.

hays

RAMBLINGS ON INSTRUMENTATION

One-upmanship in flow measurement

Never ones to ignore a trend, we have taken cognizance of Industry's increasing reliance on psychologists, motivation researchers and sociologists. These head-shrinkers are telling the Boss how to solve all kinds of problems he never knew he had. Not to be one-upped by our competitors, Hays has retained Dr. Ernest Krankenkopf, the noted author of "Socio-Economic Implications of the Electric Toothbrush" and "Behaviorism of Power-Mower Users in Scranton". Doctor Krankenkopf's first assignment was to put our Hays Electromagnetic Flowmeter on the couch, so to speak, and give us a complete report, sparing no feelings. You really should get the following in the doctor's schmaltzy Austrian accent but here's his report:

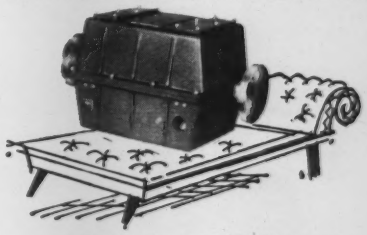
"First, we got to understand that the people who buy flowmeters are basically insecure. Why? Because they don't know how much of that banana oil or vodka or what have you is flowing through there. This insecurity leads to frustration, causing the subject to buy some kind of device to assure him everything is okay. (I'm trying to keep this simple so even your *dumbkopf* advertising manager understands, okay?)

"Now we got to understand our median subject falls in the upper-middle class on the socio-economic scale, has 2.7 kids and regards his stereo set as a mother-image.

"Now if he picks the wrong flowmeter this subject is in for real trouble. Some of these flowmeters are so complicated they make our subject feel inferior. We have observed this same phenomenon when a man buys a French poodle. He knows, deep within, that damn finicky dog is higher up on the socio-economic scale than he is! Same with flowmeters, no difference. So he reacts by kicking coke machines and manifesting other anti-authority traits.

"With the Hays Electromagnetic Flowmeter we find no such behavioral problems. Here we got an instrument

HAYS ELECTROMAGNETIC FLOWMETER



. . . not a poodle but a St. Bernard.

that's nice and simple—but with its rugged, obstruction-free construction, and ½% system accuracy you get dependability like a St. Bernard yet.

"And we find favorable status associations. With no complex calibration needed, you just pipe it up, flip the switch and take a reading. This puts the Hays Electromagnetic Flowmeter definitely in the country-club set, but not *too* snooty like polo, you dig me? Also its 10-1 range adjustment in three-step or continuous form and the fact it has a pre-amp which can be mounted at the recorder, or the transmitter or in between seems to project a Big Brother image.

"Among subjects using the Hays Electromagnetic Flowmeter we find a high coordination of good social adjustment, intra-family stability and strong career orientation. (To be honest, our survey also digs up some real weird-o's who buy your product but this you got to expect.)

"My next project is to depth-interview some engineers about your BTU meter. Already I got suspicions we find subliminal connotations of Jayne Mansfield or maybe Tuesday Weld.

"Bill enclosed. *Gesundheit!*"

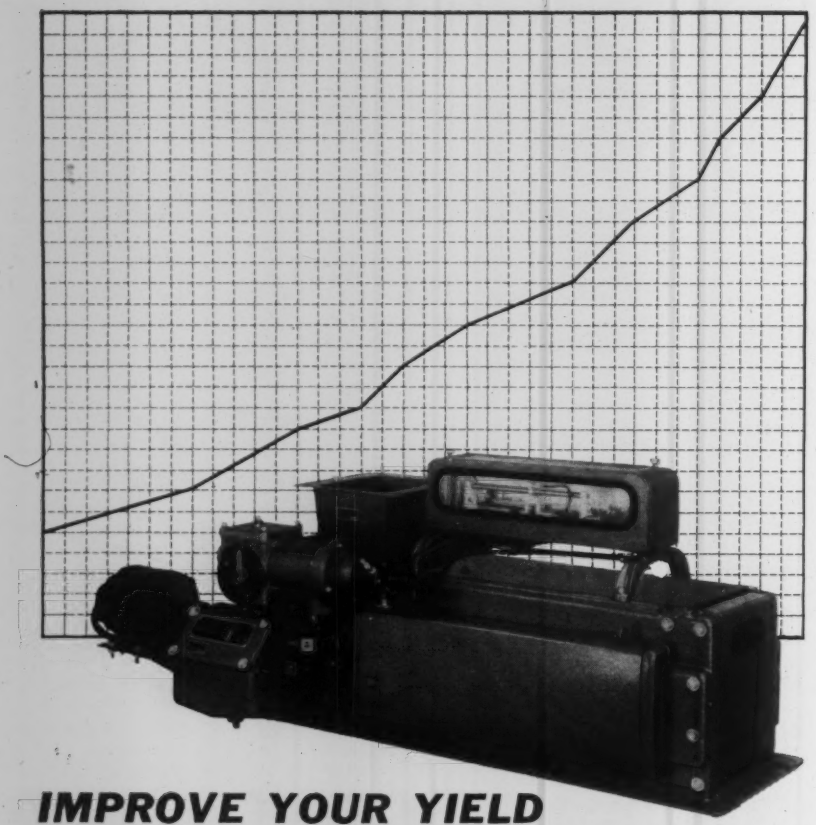
Ernest A. Krankenkopf,
PhD, DD, MD, DDS, ODO

The meaning of the above is clear: buy a flowmeter you can live with. For interesting reading while waiting for the analyst, send for our Spec Sheet B 346.

Phil A. Sprague
President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

CIRCLE 6 ON READER-SERVICE CARD



IMPROVE YOUR YIELD WITH 99% FEEDING ACCURACY...

THE W&T MERCHEN FEEDER

If you need accurate control of dry, free flowing materials to keep process yields high, count on the W&T Merchen Feeder. The Merchen controls dry flow to a hairsbreadth, hour after hour.

Pick any minute any time in your run. Pick one at high capacity, another at low capacity. The Merchen holds accuracy to ±1% from minute to minute . . . stretches the minutes into hours of precise feeding. You solve tough feeding and continuous-blending problems, get sure quality control.

Accuracy comes from sensitivity. And a change of just one ounce in a 63-pound belt load actuates the Merchen's control mechanism. It responds instantly. Accuracy is assured.

This versatile Wallace & Tiernan Feeder has other advantages: It's a straight gravimetric feeder; it feeds and controls other equipment; or it feeds in proportion to any 3-15 psi signal. Corrosion-resistant construction lets it handle most chemicals. And even the largest model occupies less than 3 x 5 feet of floor space.

For more information, write Dept. M-64.48.

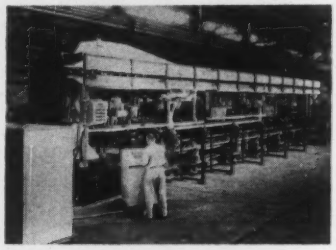
WALLACE & TIERNAN INC.

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 7 ON READER-SERVICE CARD

Automated Pipe Finishing

PHILADELPHIA, PA.—Baldwin-Lima-Hamilton's Industrial Equipment Division has developed a new system for automatic weighing, measuring, and identification for pipe finishing mills. Consisting of a complete mechanical installation for mill handling of heavy pipe, a special-purpose



computer, instrumentation and controls, pipe is accepted in lengths to 50′ 2″ and in diameters of 4-½″ to 10¾″, is length-measured to accuracy with ±½″; weighed to within 1/10th of 1%, and stenciled, all automatically. The machine prints a record for each individual pipe. It also counts total pieces, computes weight-per-foot, indicates and prints total accumulated weight and length, and can be made to perform other functions. The electro-mechanical instrumentation system was especially developed for steel mill conditions to B-L-H specifications by Telechrome Manufacturing Corporation, of Amityville, L. I., N. Y.

CIRCLE 184 ON READER-SERVICE CARD

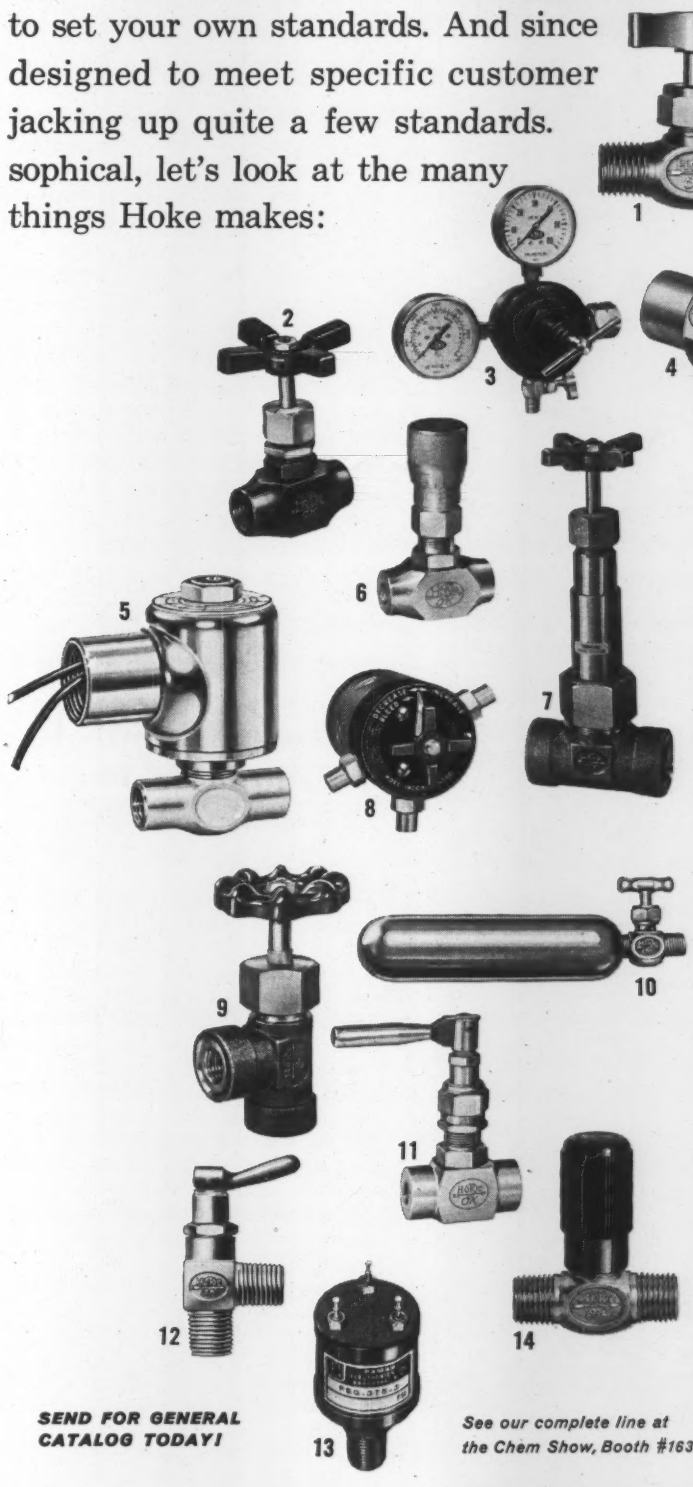
GEORGIA INSTITUTE OF TECHNOLOGY will hold a short course in Automation, Computers, and Instrumentation February 12-16, 1962, sponsored jointly by its School of Industrial Engineering and the ISA. Fee is $125.00. Application to Director Short Courses and Conferences, Georgia Institute of Technology, Atlanta 13, Georgia.

Mallinckrodt Chemical Works, St. Louis, has installed an **RCA 301 electronic data system** at its St. Louis headquarters for faster processing of mounting paperwork. The fully-transistorized computer system will be used initially to handle general accounting work and sales analyses. Much of the computer programming involved the use of COBOL, the Common Business Oriented Language technique developed under Federal sponsorship.

CIRCLE 185 ON READER-SERVICE CARD

diversity

A business school prof might call it product diversification to broaden the marketing base, but it all boils down to the basic American drive for a better standard of living. But, all is not so crass! This base broadening business brings *you* the products you need to set your own standards. And since most of our products were designed to meet specific customer demand, we've had a hand jacking up quite a few standards. Before we get too philosophical, let's look at the many things Hoke makes:



1 FORGED NEEDLE VALVES 300 Series:
3000 psi
Brass, 303 SS, 316 SS, Monel
Aluminum 1/8" to 3/8" NPT and with integral tube fittings

2 BAR STOCK NEEDLE VALVES 270 Series:
3000 to 5000 psi
Brass, 430F SS, 316 SS, carbon steel, carbon steel and SS
1/8" to 1/2" NPT and with integral tube ends

3 PRESSURE REGULATORS 680 Series (gen'l purpose):
Max. delivery press. 140 psig
Max. inlet press. 2500 psig
1/4" NPT male needle valve outlet Std. CGA inlet

4 CHECK VALVES 570 and 580 Series:
2000, 3000, 5000 and 6000 psi
Brass, 303 SS
1/8" to 1/2" NPT and with integral tube fittings.
Ball and piston types

5 SOLENOID VALVES Series 90 (2-way type): Series 95 (3-way type):
Differential press. ratings to 2000 psi
Brass, 303 SS
1/8" and 1/4" NPT or JIC tube connections
Choice of coils, housings, corrosion-resistant trim

6 BAR STOCK NEEDLE VALVES 280 Series (metering):
3000 psi
Brass, 316 SS
1/8" and 1/4" NPT
1/16" and 1/8" orifice

7 PACKLESS VALVES 473 Series (bellows seal):
400 and 2000 psi
316 SS
1/2" NPT

8 PRESSURE REGULATORS 920 Series (ballast operated):
Max. del. press. 4500 psig
Max. inlet press. 5000 psig
1/4" NPT inlet and outlet

9 FORGED NEEDLE VALVES 100 Series
10,000 psi (WOG)
Weldable forged carbon steel
1/8" to 1/2" NPT

10 SAMPLING CYLINDERS
Service press. 400 and 1800 psi
304 SS
1/8" to 1/2" NPT outlet
Single or double valve types
Sizes 10 ml. to 1 gallon

11 TOGGLE VALVES 490 Series (cam-closing):
1000 and 2000 psi
Brass, 303 SS
1/8" to 1/2" NPT

12 TOGGLE VALVES 450 Series (spring-closing):
200 psi
Brass, 303 SS
1/8" to 3/8" NPT and with integral tube fittings

13 PRESSURE SWITCHES PSG-375 Series:
Operating range 15 psig to 500 psig (max. setting)
Aluminum and SS housing
Proof Press.— 150% max. operating pressure
Burst Press.— 250% max. operating pressure
1/8" NPT port or AND 10056-4, 37½° flare

14 PACKLESS VALVES A431 Series (brass bellows seal):
400 psi
Brass
1/8" and 1/4" NPT

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Here's a major advance in DC signal amplifier design that gives you the HIGHEST GAIN available today—combined with a wider temperature range, a smaller sized package, and unequalled stability! The new versatile SA9-0 provides complete utilization of low-level DC signals from thermocouples, thermal sensing to bridges and DC excited transducers, etc. It gives you the utmost in dependability under extreme environmental conditions. Modular construction makes the compact transistorized SA9-0 ideal for airborne applications requiring multiple channel installation in limited space. Write for complete technical data!

GAIN:	Continuously variable from 50 to 500. (Special models up to 1000)
TEMPERATURE RANGE OPERATING:	−65° F. to +165° F.
NON-OPERATING:	−65° F. to +225° F.
THERMAL COEFFICIENT OF SENSITIVITY:	0.02% /° F.
THERMAL ZERO SHIFT:	0.01% /° F. of full scale output.
OUTPUT:	0 to 5 V DC
INPUT REQUIREMENTS:	0 to 5 mv DC.
POWER REQUIREMENTS:	30 ma at 28 V DC ±10%.
WEIGHT:	8 oz. (approx.)
SIZE:	less than 8 cu. in.

Statham ELECTRONICS EDD DIVISION

Statham Instruments, Inc., 12401 W. Olympic Blvd.
Los Angeles 64, Calif. / GRanite 8-0361 / TWX: West Los Angeles CAL 6602

CIRCLE 9 ON READER-SERVICE CARD

Records Rapid Events from Annunciator

INDIANAPOLIS, IND.—Cleveland Electric Illuminating Company's 215,000-kw turbo-generator, recently installed at the Avon Lake power plant, is equipped with automatic controls linked to an annunicator board. In operation, the controls tripped circuits so rapidly that it was impossible to determine the sequence or the elapsed time between each trip. To find out what tripped when, and if it tripped at the proper time, engineers installed event recorders (Esterline Angus Instrument Company, Box 596, Indianapolis, Ind.). The recorders provide a record of when valves and circuit breakers are opened or closed or when fans and feedwater pumps start or stop, even if the events occur one after another in seconds.

CIRCLE 186 ON READER-SERVICE CARD

THE 1962 JACC (Joint Automatic Control Conference), to be held June 27-29, 1962 at the New York University, will accept text of papers to November 15, 1961 through headquarters of the author's sponsoring society.

Process Control Computer For Pulp Mill

SCHENECTADY, N. Y.—Southern Land Timber & Pulp Corporation has purchased a General Electric-312 process computer for installation in its new, 700 ton-per-day kraft linerboard mill at Cedar Springs, Ga. The computer will first be used for automatic direction of on-line information processing and production control. Conventional instruments and control systems will be used to perform most real-time functions to free the computer as much as possible for multi-variable information processing. Functions to be performed by the computer system include: (1) logging of approximately 450 pieces of process data from all areas of the mill; (2) monitoring to provide close surveillance of process variables for off-normal conditions; (3) preparation of management reports of a timely nature; (4) performing complex calculations on input information; and (5) providing output control for selected mill processes.

- "Sees" small areas, down to 0.080 inches
- Easy to focus and zero-in on target; reticle in telescopic sight exactly frames target
- Precision (repeatability) of 0.6% of temperature
- Fast: 0.3 seconds for 95% response
- Pushbutton temperature calibration at control panel
- Adjustment for emissivities from 0.2 to 1.0
- 0-10 millivolt output for recorders, indicators and controllers

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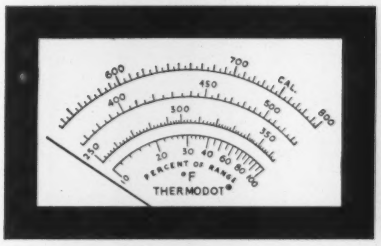
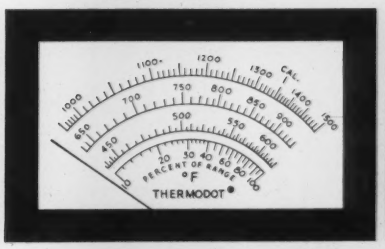
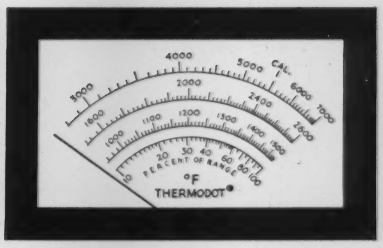


430-1500°F



970-7000°F



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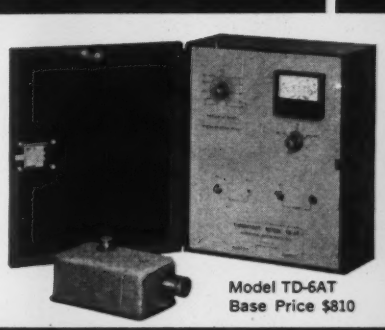

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NEW YORK COLISEUM
NOVEMBER 27–DECEMBER 1

PROBLEM: how to collect, record and transmit critical fluid flow data more *accurately* than ever before.

SOLUTION: custom-designed flow measurement systems from General Electric.

RESULT: reliable process control, simplified fluid accounting, precision batch blending and loading.

System instrumentation includes: true mass flowmeter, available in 13 standard ranges ■ null balance recorders, a full line of strip and round-chart ■ new telemetering equipment, analog and digital.

In addition, ticket printers and totalizing counters are available for visual digital display and pre-set counters may be added to provide precision control in blending and loading operations.

FOR FLUID FLOW PROCESS:

In a variety of system applications, these General Electric instruments cut operating costs and boost plant production . . . through *simplified* and *more accurate* measurement. No wonder they've been specified by process engineers throughout the world. *Performance-proved . . . on the line!*

For complete information, contact your nearby General Electric sales office or write Section 599-08, General Electric Co., Schenectady 5, N. Y. for the following bulletins: GEA-6925, Mass Flowmeter; GEA-6887, Null Balance Recorders; GEA-7163, Telemetering Systems. In Canada, contact Canadian G.E. Co. Ltd., 940 Lansdowne Ave., Toronto 4, Ontario. Outside the U.S. and Canada, contact International G.E. Co., 150 E. 42nd St., New York 14, N. Y.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

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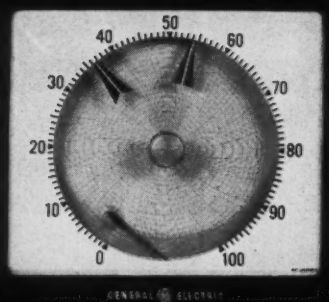
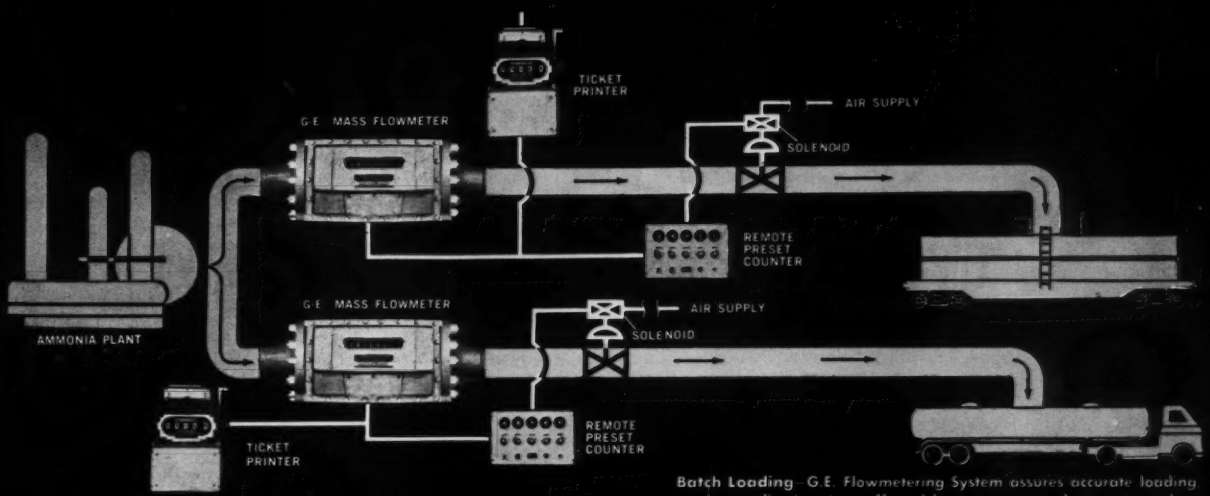
Mass Flowmeter measures fluid flow directly in pounds, eliminates volume-to-mass conversion. ±1% accuracy unaffected by change in pressure, density, temperature, viscosity, flow rate. 13 standard ranges now available.

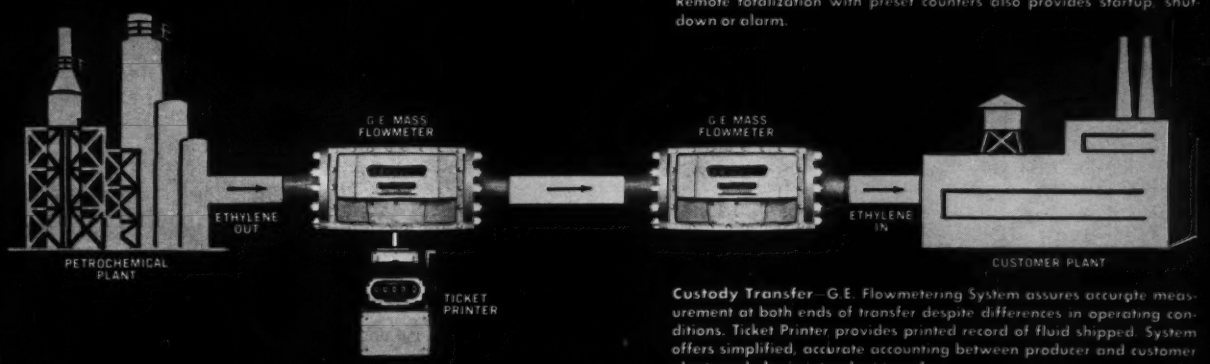
HIGH ACCURACY



General Electric Null Balance Recorders feature: silicon diode reference voltage source for operational reliability; varied control forms for versatile applications; components mounted on swing-out panel to simplify routine maintenance. Full line includes multipoint, single and two-pen—strip or round-chart models.

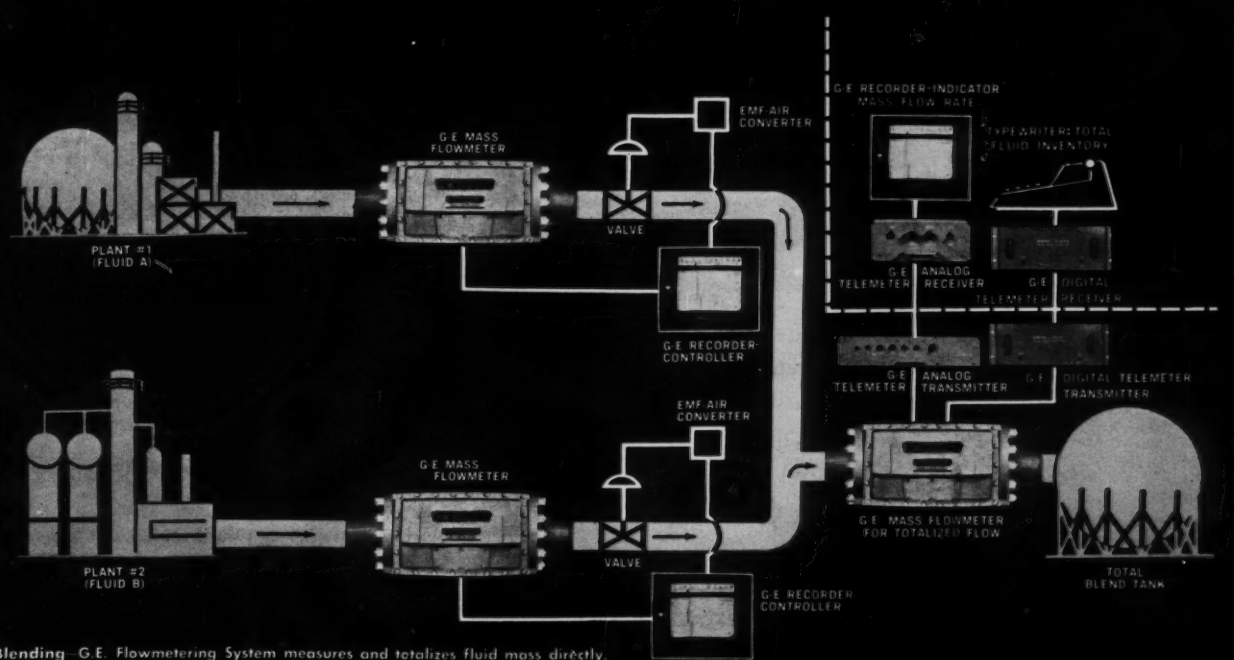


Batch Loading—G.E. Flowmetering System assures accurate loading, precise totalization; is unaffected by temperature changes in tank or pipe. Meter measures different fluids with no calibration change. Remote totalization with preset counters also provides startup, shutdown or alarm.



Custody Transfer—G.E. Flowmetering System assures accurate measurement at both ends of transfer despite differences in operating conditions. Ticket Printer provides printed record of fluid shipped. System offers simplified, accurate accounting between producer and customer plants and also in interplant transfers.

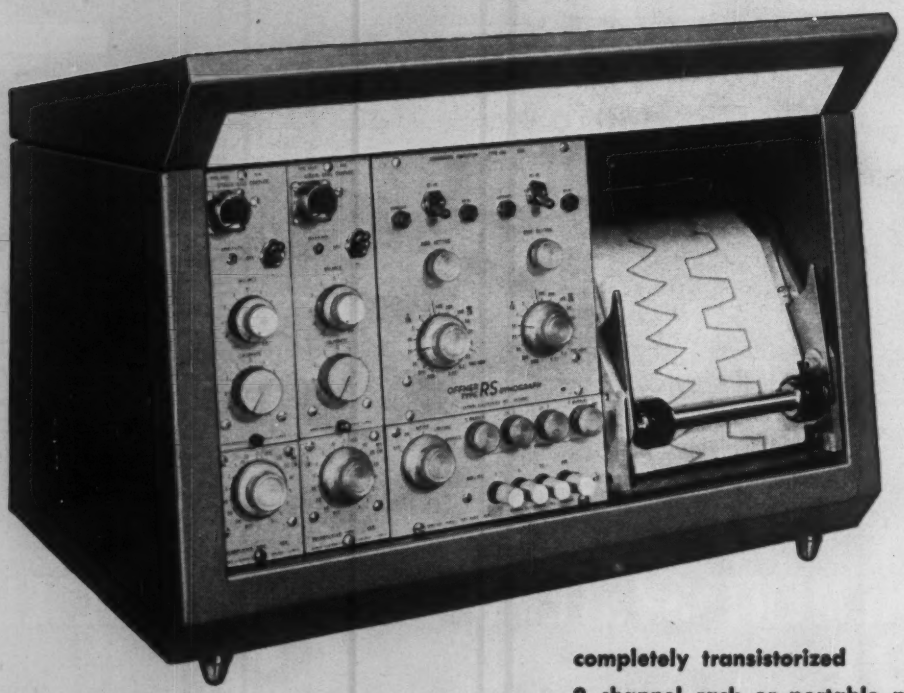
MEASUREMENT SYSTEMS FROM GENERAL ELECTRIC



Fluid Blending—G.E. Flowmetering System measures and totalizes fluid mass directly, eliminates laborious volume-to-mass conversions. Predetermining counters assure simplicity and accuracy in blending operations. Data is instantly telemetered to central locations by new G-E Telemetering. Typical blends are refrigerants, solvents and special naphthas.

OFFNER

TYPE RS DYNOGRAPH



completely transistorized
2 channel rack or portable mounting
unmatched accuracy and versatility

25 years ago Offner invented the world's first Direct-Writing Oscillograph.

25 YEARS

Microvolt sensitivity, unmatched accuracy and compact design are combined with exceptional versatility in this completely new two channel Type RS Dynograph.

All-transistorized, table or rack mounted, conveniently carried for portable use, the Type RS Dynograph provides the same exceptional performance specifications as the Offner Type R Dynograph. Write for complete details.

Sensitivity: With preamplifiers, 10 microvolts per cm to 50 volts per cm.
Warm-up: Instantaneous.
Drift: One microvolt per hour pen drift at maximum sensitivity.
Ambient Temperature Range: —20° to +60° C.
Frequency Response: Within 10% to 150 cps, and 20% to beyond 200 cps.
Recording Media: Rectilinear Heat or Electric, Curvilinear ink or electric, easily converted.
Deflection Time: 2.5 MS with preamplifiers, 1.5 MS without.

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OFFNER DIVISION
of Beckman Instruments, Inc.

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CIRCLE 12 ON READER-SERVICE CARD

BOOKS

Analysis of Nonlinear Control Systems by Dunstan Graham & Duane McRue, [c1961] John Wiley & Sons, Inc., 440 Park Ave. South, New York 16, N. Y. 482 pp., 9″, clothbound, $9.75.

CIRCLE 187 ON READER-SERVICE CARD

The Mechanics of Inertial Position Heading Indication by Winston Markey & John Hovorka [c 1961] John Wiley & Sons, Inc., 440 Park Ave. South, New York 16, N. Y. 94 pp., 8½″, clothbound, $3.95.

CIRCLE 188 ON READER-SERVICE CARD

The Handbook of Thermophysical Properties of Solid Materials, Vol. 2, edited by Alexander Goldsmith, Thomas E. Waterman, and Harry J. Hirschorn, published by special arrangement with U. S. Air Force, The Macmillian Co., 60 Fifth Ave., New York 11, N. Y. 1270 pp., 11″, clothbound, $90.00.

CIRCLE 189 ON READER-SERVICE CARD

The Story of X-Rays by Alan Ralph Bleich [c 1961], Dover Publications, Inc., 180 Varick St., New York 14, N. Y. 186 pp., 8″, paperbound, $1.65.

CIRCLE 190 ON READER-SERVICE CARD

The Story of Atomic Theory and Atomic Energy by J. G. Feinberg, 1960] Dover Publication Inc., 180 Varick St., New York 14, N. Y., 264 pp., 8″, paperbound, $1.45.

CIRCLE 191 ON READER-SERVICE CARD

Coordinate Geometry by Luther Pfahler Eisenhart, republished by Dover Publications Inc., 180 Varick St., New York 14, N. Y. 298 pp., 8″, paperbound, $1.65.

CIRCLE 192 ON READER-SERVICE CARD

Statistical Dynamics of Automatic Control Systems, by V. V. Solodovnikov, translation edited by John B. Thomas and Lofti A. Zandeh, [c 1960] Dover Publication Inc., 180 Varick St., New York 14, N. Y. 307 pp., 8″, paperbound, $2.25.

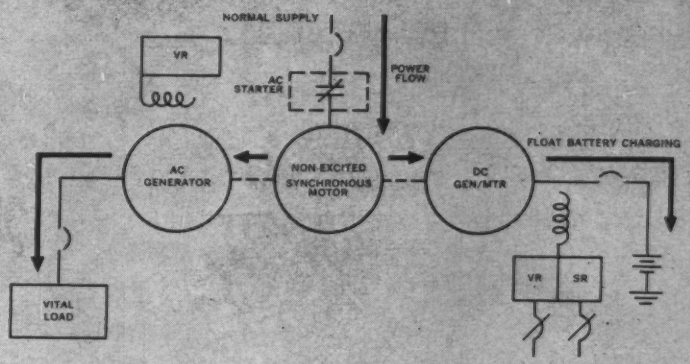
CIRCLE 193 ON READER-SERVICE CARD

Understanding Digital Computers by Paul Siegel, [c 1961] John Wiley & Sons, Inc., 440 Park Ave. South, New York 16, N. Y. 403 pp., 9″, clothbound, $8.50.

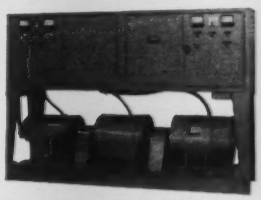
CIRCLE 194 ON READER-SERVICE CARD

The Scientific Papers of J. Willard Gibbs, Vol. I, Thermodynamics, republished by Dover Publications, 180 Varick St., New York 14, N. Y. 434 pp., 8½″, paperbound, $2.00.

CIRCLE 195 ON READER-SERVICE CARD



HOW A COSTLY VACCINE IS PROTECTED IN PROCESS BY A KEARFOTT UNINTERRUPTED POWER SYSTEM



The AC generator rating of this Kearfott installation is 5 KW, 3 phase, 60 cycle, 120/208 volt.

The system pictured above is typical of many which Kearfott has furnished to prevent power failures or fluctuations from affecting the fine, continuous control necessary in certain vulnerable manufacturing processes. The user, a Polio Vaccine producer, regulates virus growth with the help of infrared and radiant heat devices that cannot tolerate any loss of electrical power.

Here, a non-excited synchronous motor operated on the normal power drives both an AC and a DC generator. The output of the former is to the vital load, while that of the latter is used to maintain the batteries in fully charged condition. In the event of main power failure, the DC generator operates as a motor, drawing current from the batteries to drive the AC generator. When main power returns, the system automatically returns to normal operation. When on normal, the system maintains output to the vital load within ±1% of rated values regardless of input power supply variations.

Generator ratings to 150 KVA 60 and 400 cycles, single and polyphase. Frequency, voltage and transfer regulation as required by the application.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

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Specially processed wire
for use in SHEATHED
THERMOCOUPLE
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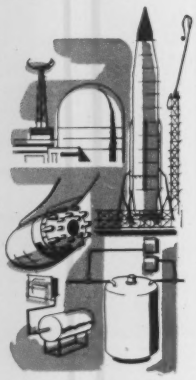
Chromel-Alumel®

SPECIFICATION 3G-220
THERMOCOUPLE ALLOYS

One good reason for the fine reliability of sheathed thermocouple assemblies—in heat treating and chemical processing applications, jet engines, missiles, and nuclear reactors—has been the development of Hoskins Specification 3G-220 Chromel and Alumel wire. It's a special grade of material produced specifically for swaged, rolled or drawn sheathed unit construction. And all that's required to overcome adverse effects of such cold-working operations on its emf properties is a simple, quick heat treatment after fabrication.



A brand new 36-page catalog-manual contains detailed technical data on this and the complete "family" of time-tested Chromel-Alumel thermocouple, lead-wire, and mechanical grade alloys. Want a copy?

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The Scientific Papers of J. Willard Gibbs, Vol. II, Dynamics, Vector Analysis and Multiple Algebra, Electromagnetic Theory of Light, etc., republished by Dover Publications, 180 Varick St., New York 14, N. Y. 434 pp., 8½″, paperbound, $2.00.

CIRCLE 196 ON READER-SERVICE CARD

Vestor Analysis based on lectures by J. Willard Gibbs, by Edwin Bidwell Wilson, republished by Dover Publications, 180 Varick St., New York 14, N. Y. 434 pp., 8″, paperbound, $2.00.

CIRCLE 197 ON READER-SERVICE CARD

Elementary Principles in Statistical Mechanics by J. Willard Gibbs, republished by Dover Publications, 180 Varick St., New York 14, N. Y., 434 pp., 8″, paperbound $2.00.

CIRCLE 198 ON READER-SERVICE CARD

Handbook of Automation Computation and Control, Vol. 3, Systems and Components, edited by Eugene M. Grabbe, Simon Ramo, and Dean E. Wooldridge, John Wiley & Sons, Inc., 440 Park Ave. South, New York 16, N. Y. 952 pp., 9″, clothbound.

CIRCLE 199 ON READER-SERVICE CARD

Algebras and their Arithmetics by Leonard Eugene Dickson, [c 1960] Dover Publications, Inc., 180 Varick St., New York 14, N. Y. 241 pp., 8″, paperbound, $1.35.

CIRCLE 200 ON READER-SERVICE CARD

The Nature of Science by David Greenwood, [c 1959] Philosophical Library, Inc., 15 E. 40 St., New York 16, N. Y. 95 pp., 7¼″, clothbound, $3.75.

CIRCLE 201 ON READER-SERVICE CARD

A-C Motor Control Fundamentals by R. L. McIntyre, [c 1960] McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y. 248 pp., 9″ clothbound, $5.95.

CIRCLE 202 ON READER-SERVICE CARD

Transistors and Active Circuits by John G. Linvill and James F. Gibbons, [c 1961] McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y. 515 pp., 9″, clothbound, $14.50.

CIRCLE 203 ON READER-SERVICE CARD

Semiconductor Devices and Applications by R. A. Greiner, [c 1961] McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y. 493 pp., 9″, clothbound, $12.50.

CIRCLE 204 ON READER-SERVICE CARD

Adaptive Control Systems, edited by Eli Mishkin and Ludwig Braun, Jr., [c 1961] McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y. 533 pp., 9″, clothbound, $16.50.

CIRCLE 205 ON READER-SERVICE CARD

3 TIMES FASTER CYLINDER PISTON RETURN

THAN WITH COMPARABLE SOLENOID VALVES

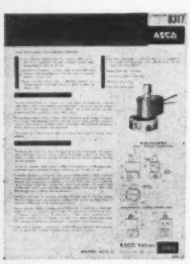
ASCO MIDGET 3-WAY—ACTUAL SIZE

OVERSIZE EXHAUST

NORMALLY OPEN NORMALLY CLOSED, OR UNIVERSAL OPERATION

MOUNTS IN ANY POSITION

ONLY 2 MOVING PARTS



The ASCO Bulletin 8317 Solenoid Valve provides the fastest cylinder or diaphragm return of any valve its size. For example, at 100 psi a 12" return stroke in a 3" cylinder takes 2½ seconds with the 8317 . . . 7 seconds with a comparable valve. This remarkable 3-way solenoid valve can be substituted for larger, more expensive units normally required to obtain fast return.

In other 3-way valves, the fast rate of flow under pressure usually provides quick operation of the cylinder or diaphragm, but the dissipation of pressure on exhaust results in a slower return stroke. The large exhaust orifice on the Bulletin 8317 (over 7 times greater than the inlet area) quickly vents the pressure, permitting the piston or diaphragm to return rapidly.

The ASCO Bulletin 8317 has only 2 moving parts . . . mounts in any position . . . is available in normally open, normally closed and universal construction . . . with general-purpose, explosion-proof or watertight solenoid enclosures in ¼" pipe size . . . for pressures up to 160 psi . . . for water up to 100° F. or air, gases and light hydraulic oil up to 180° F. It is immediately available from stock, as are other ASCO solenoid valves.

WRITE FOR BULLETIN 8317, providing complete descriptive information on this new, "midget," quick-exhaust 3-way.

ASCO Valves

ASCO

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CIRCLE 23 ON READER-SERVICE CARD

COUNT ON THE NEW W&T SERIES 100 PUMP WHEN YOU NEED...

...ACCURATE METERING WITH SMOOTH CONTROL

Wallace & Tiernan's newest plunger pump delivers 3.2 gph vs 1200 psi to 50 gph vs 100 psi, repeatable within ± 1%. Easy adjustment over 10:1 range with the pump running.

...DOUBLE CAPACITY OR TWO-LIQUID METERING

A second liquid end doubles capacity or gives simultaneous feeding of two liquids. Stroke length for each end individually adjusted.

...DEPENDABLE, TROUBLE-FREE METERING

Unitized construction means the Series 100 Pump stays in perfect alignment. Wear and maintenance are held to a minimum. Corrosion-resistant wetted parts handle most chemicals. The Series 100 Pump, with motor, is compact. With two liquid ends it occupies less than 2 sq. ft.

For more information write Dept. L-8.48

WALLACE & TIERNAN INC.

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 16 ON READER-SERVICE CARD

Lichtstrahl Oszillographen (Light-beam Oscillographs) by W. Hartel, J. Degenhart, A. Kubler, Chr. Sorensen, and J. Troger, [c 1961] R. Oldenbourg Verlag GmbH, 145 Rosenheimer Str., Munich, West Germany. 462 pp., 9¼", clothbound, DM64.00.

CIRCLE 206 ON READER-SERVICE CARD

Einfuhrung in die Theorie der Abtastsysteme (Introduction to the Theory of Scanning Systems) by Johann Tschauner, [c 1960] R. Oldenbourg Verlag GmbH, 145 Rosenheimer Str., Munich, West Germany, 185 pp., 9¼", paperbound, DM32.00.

CIRCLE 207 ON READER-SERVICE CARD

Ein kombiniertes Regelsystem fur die Verfahrensindustrie (A Combined Control System for the Process Industry), [c 1960] R. Oldenbourg Verlag GmbH, 145 Rosenheimer Str., Munich, West Germany. 204 pp., 9¼", clothbound, DM24.00.

CIRCLE 208 ON READER-SERVICE CARD

Cybernetics, or Control and Communication in the Animal and the Machine, Second Edition, by Norbert Wiener, [c 1961] Massachusetts Institute of Technology, John Wiley & Sons, Inc., 440 Park Ave. South, New York 16, N. Y. 212 pp., 9", clothbound, $6.00.

CIRCLE 209 ON READER-SERVICE CARD

Practical Microscopy by C. L. Duddington [c 1960], Pitman Publishing Co., 2 W. 45 St., New York 36, N. Y. 237 pp., 8½", clothbound, $6.50.

CIRCLE 210 ON READER-SERVICE CARD

Vacuum Tube Voltmeter Assembly Manual, [c 1961] Lafayette Electronics Manufacturing Corp., 165-08 Liberty Ave., Jamacia 33, N. Y. 56 pp., 11", paperbound, 50c.

CIRCLE 211 ON READER-SERVICE CARD

Engineering Approach to Gyroscopic Instruments by E. J. Siff, and Claude L. Emmerich [c 1960], Robert Speller & Sons, Publishers, Inc., New York 36, N. Y. 120 pp., 9", clothbound, $7.50.

CIRCLE 212 ON READER-SERVICE CARD

Radio Control Manual, by Edward L. Safford, Jr., [c 1961] Gernsback Library, Inc., 154 W. 14 St., New York 11, N. Y. 192 pp., 8½", paperbound $3.20.

CIRCLE 213 ON READER-SERVICE CARD

A to Z in Audio by G. A. Briggs (technical editor R. E. Cooke) [1961] Gernsback Library, Inc., 154 W. 14 St., New York 11, N. Y. 24 pp., 8½", paperbound, $3.20, clothbound $5.00.

CIRCLE 214 ON READER-SERVICE CARRD

Filter and Attenuators, edited by Alexander Schure, [c 1961] John F. Rider Publisher, Inc., 116 W. 14 St., New York 11, N. Y. 96 pp., 8½", paperbound, $2.25.
CIRCLE 215 ON READER-SERVICE CARD

Computer Engineering, edited by S. A. Lebedev, translated by Jane Stuart, [c 1960] Pergamon Press Inc., 122 E. 55 St., New York 22, N. Y. 184 pp., 8½", clothbound, $10.00.
CIRCLE 216 ON READER-SERVICE CARD

Semiconductor Reliability, edited by John E. Shwop and Harold J. Sullivan, [c 1961] Engineering Publishers, Div. of the AC Book Co., Inc., P. O. Box 2, Elizabeth, N. J. 309 pp., 9", clothbound, $8.50.
CIRCLE 217 ON READER-SERVICE CARD

Solution of Equations and Systems of Equations by A. M. Ostrowski, [c 1960] Academic Press Inc., Publishers, 111 Fifth Ave., New York 3, N. Y. 202 pp., 9", clothbound, $6.80.
CIRCLE 218 ON READER-SERVICE CARD

pH Measurement and Titration by G. Mattock, [c 1961] Heywood & Co., Ltd., The Macmillan Co., 60 Fifth Ave., New York 11, N. Y., 406 pp., 8½", clothbound, $14.50.
CIRCLE 219 ON READER-SERVICE CARD

Ultrasonics and its Industrial Applications by O. I. Babikov, [c 1960] Consultants Bureau Enterprises, Inc., 227 W. 17 St., New York 11, N. Y. 224 pp., 9", $9.75.
CIRCLE 220 ON READER-SERVICE CARD

Vacuum Microbalance Techniques, Vol. 1, edited by M. J. Katz, [c 1961] Plenum Press, Inc., 227 W. 17 St., New York 11, N. Y. 152 pp., 9", clothbound, $6.50.
CIRCLE 221 ON READER-SERVICE CARD

Kinematics of Machines, Second Edition, by Rolland T. Hinkle, [c 1960] Prentice-Hall, Inc., Englewood Cliffs, N. J. 343 pp., 9", $7.50.
CIRCLE 222 ON READER-SERVICE CARD

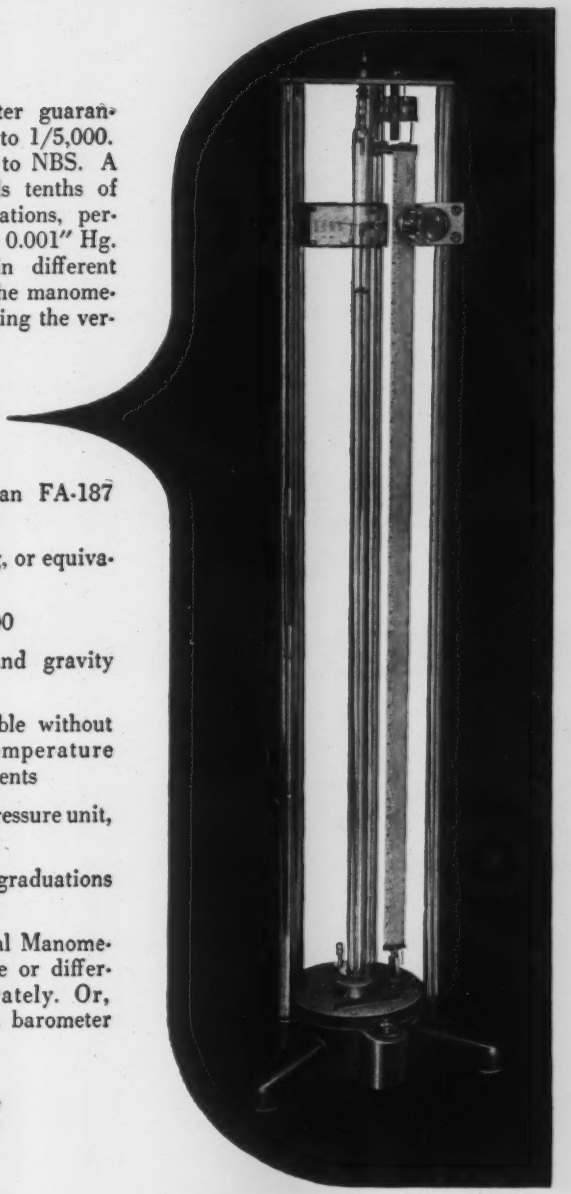
Introduction to Nuclear Engineering, Second Edition, by Raymond L. Murray, [c 1961] Prentice-Hall, Inc., Englewood Cliffs, N. J. 384 pp., 9" clothbound, $12.00.
CIRCLE 223 ON READER-SERVICE CARD

Aerospace Telemetry, edited by Harry L. Stiltz, [c 1961] Prentice-Hall, Inc., Englewood Cliffs, N. J. 505 pp., 9", $15.00.
CIRCLE 224 ON READER-SERVICE CARD

Management Control Systems edited by Donald G. Malcolm, Alan J. Rowe, and Loriner F. McConnell, [c 1960] John Wiley & Sons, Inc., 440 Park Ave. South, New York 16, N. Y. 375 pp., 9", clothbound, $7.25.
CIRCLE 225 ON READER-SERVICE CARD

Continued on page 1983

GET W&T U-Tube accuracy with Fast, Direct Readout.. PRECISION MERCURIAL MANOMETER



The FA-187 Manometer guarantees readings accurate to 1/5,000. Accuracy is traceable to NBS. A magnetic vernier reads tenths of the main scale graduations, permits direct readings to 0.001" Hg. Five vernier scales in different units allow changing the manometer scale without changing the vernier.

The Wallace & Tiernan FA-187 Manometer also gives:

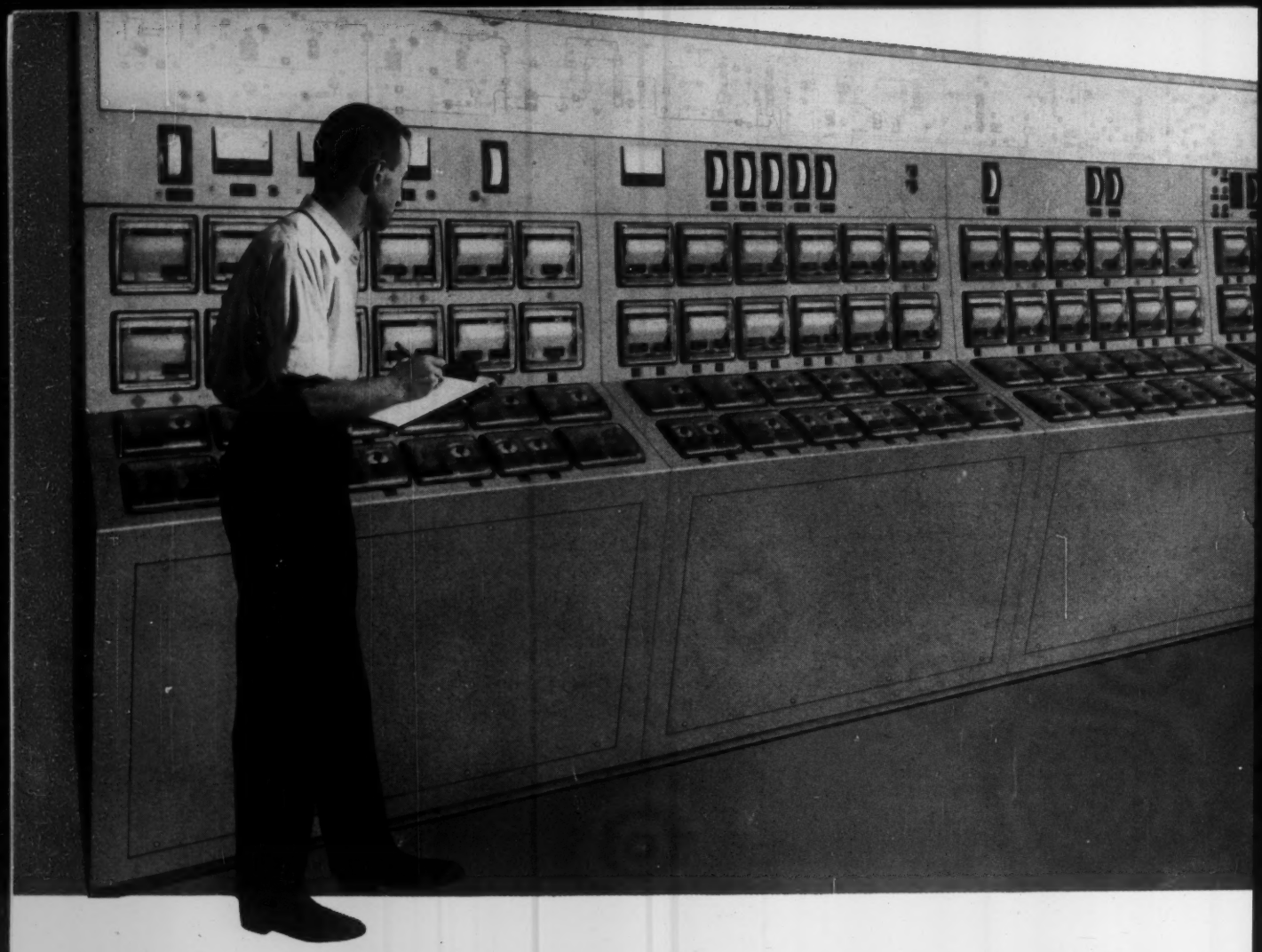
- ★ Range: 800 mm. Hg, or equivalent
- ★ Sensitivity: 1/25,000
- ★ Full temperature and gravity compensation
- ★ Scales interchangeable without recalibration of temperature and gravity adjustments
- ★ Calibration in any pressure unit, or equivalent
- ★ One or two sets of graduations on a single scale

Use the W&T Mercurial Manometer to measure absolute or differential pressures accurately. Or, quickly convert it to a barometer on the job.

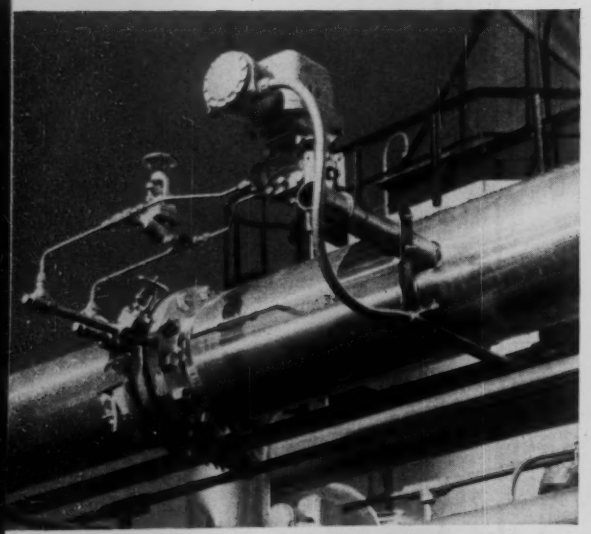
For more information, write Dept. A-134.48

WALLACE & TIERNAN INC.
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

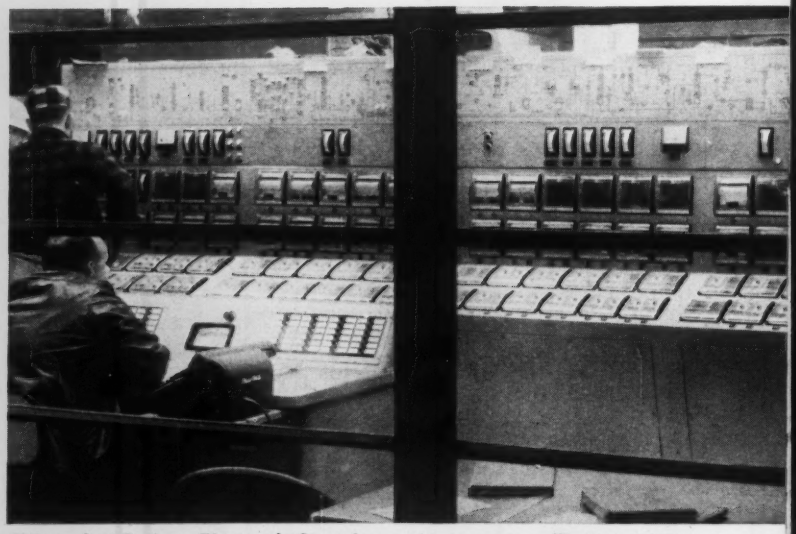
CIRCLE 17 ON READER-SERVICE CARD



Foxboro Electronic Consotrols* shrink

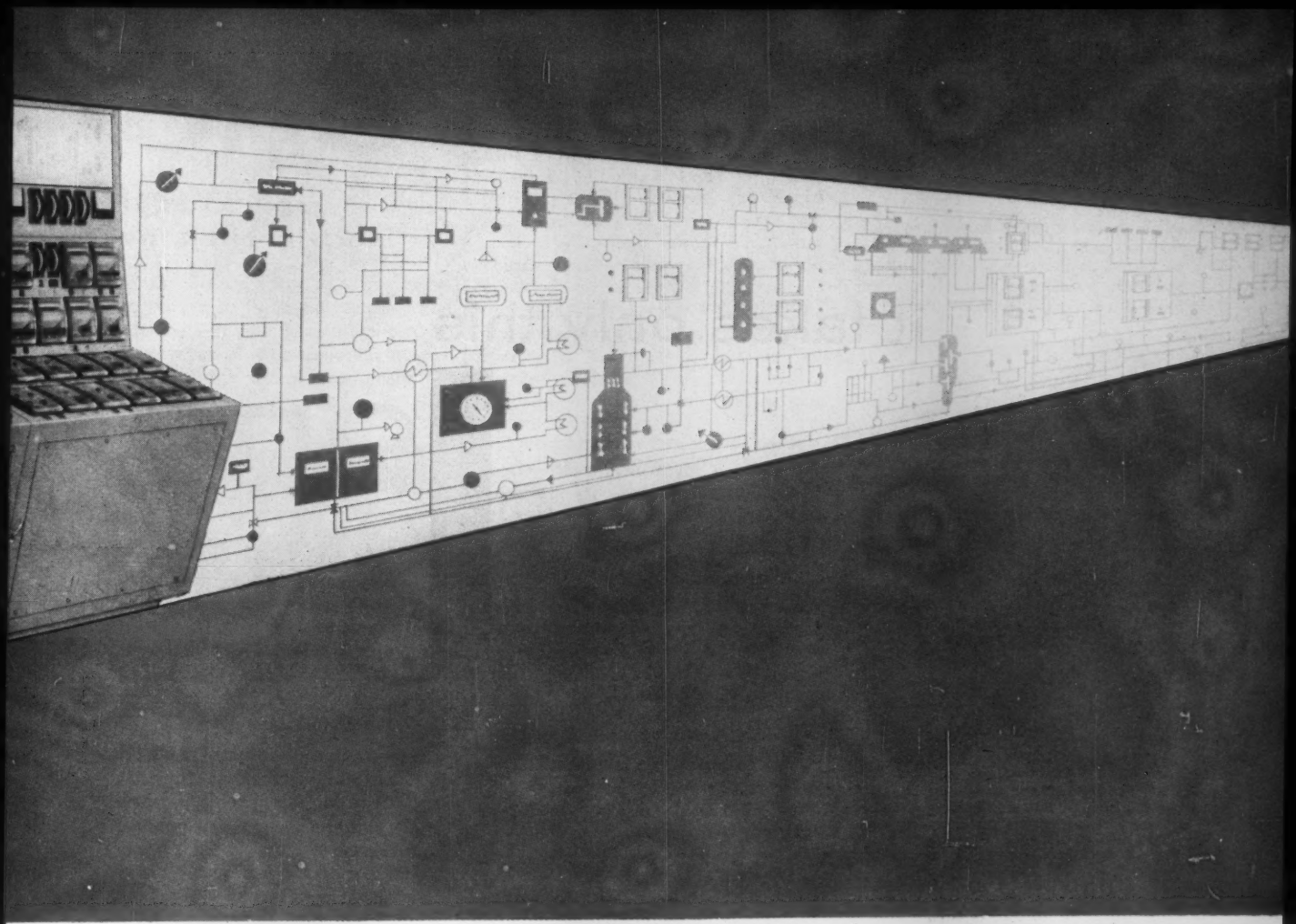


100% solid state instruments, like this Foxboro Type 613 d/p Cell* Flow Transmitter, were used in all control loops to assure instant transmission over long distances. **Reg. U. S. Pat. Off.*



Fifteen-foot Foxboro Electronic Console permits fast scanning of instruments — gives dependable control of Alkar† unit, styrene plant, and steam plant for Cosden Petroleum.

†Trade mark Universal Oil Products Co. — Process Licensor
Badger Manufacturing Co. — Contracting Engineers



panel length 66% for Cosden Petroleum

Panel planned for 45 feet, then reduced to 15 feet with Foxboro "small case" Electronic Consotrols

Space saving has taken on a new meaning at Cosden Petroleum Corp. At Cosden's Big Spring, Texas refinery, a UOP Alkar† unit, a styrene plant, and a steam plant are all electronically controlled by one 15-foot Foxboro Modular Console.

When Cosden Petroleum specified Foxboro "small case" Electronic Consotrols and modular consoles, 30 feet of panel space were eliminated for a considerable saving in building construction costs alone.

What's more, Foxboro packed 61 Electronic Consotrol Controllers, plus 100 indicating and recording points into the 15-foot panel — and there's still room to spare for tomorrow's instrumentation needs! Spare panel cut-outs for 35 more controllers and 9 more recorders are pre-wired and ready for service. All Cosden needs to do is hook up the transmitter leads at the bottom of the cabinet and slip the recorder or controller into the panel.

Maintenance men also like the easy way they can transfer instruments on the modular console. Instruments slide in and out of their housings as easily as drawers. A simple plug-in connection puts the instruments into action.

You too, can save space, save time, save money — with Foxboro Electronic Consotrols.

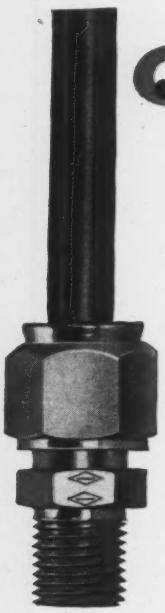
Write for Bulletin 9-12. The Foxboro Company, 4611 Neponset Avenue, Foxboro, Massachusetts.

Reg. U. S. Pat. Off.

CIRCLE 18 ON READER-SERVICE CARD

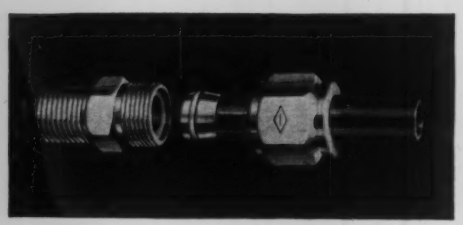
it takes only this

one



one

one versatile fitting



to meet more pressure, temperature, shock, vibration conditions than does any other tube fitting

. . . in more styles, sizes, combinations and materials than any other fitting. For more information, see next page . . . and write for Catalog 3108.

BUTT JOINT **HI-SEAL**

IMPERIAL EASTMAN

Imperial-Eastman Corporation General Offices: 6300 West Howard Street, Chicago 48, Illinois

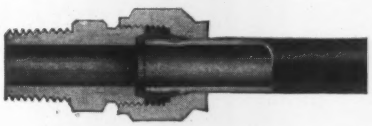
In Canada: Imperial-Eastman Corporation (Canada) Ltd., Barrie, Ontario

CIRCLE 19 ON READER-SERVICE CARD

one

tube fitting— versatile Hi-Seal®

With Hi-Seal you can overcome moderate to toughest service conditions—in one entire system or in several. With simple variations in the basic fitting, you meet al-



most every need—just specify a change in type of metal and vary the sleeve and nut. Thus, you match Hi-Seal to pressure, temperature, vibration, shock and installation variables.

50 TYPES—1300 SIZES

Hi-Seal Fittings are available in straight connectors, straight reducers, unions, adapters, elbows, tees, crosses, caps, couplings, swivel nuts, valves, port seal and Braze-Seal. Altogether there are almost 50 types—collectively more than 1300 sizes, generally from 1/16" tube O.D. to 1½". Metals available include steel, stainless steel, brass, aluminum, titanium, Monel and others. Combinations are almost endless!

Now Imperial-Eastman meets all your requirements for hydraulic-pneumatic-flow system components: tube fittings, valves, couplings, flexible and rigid hydraulic and pneumatic lines, thermoplastic tubing, tubing tools.

See Imperial-Eastman first!

FITTINGS

IMPERIAL-EASTMAN

Books, continued

How to Fix Transistor Radios and Printed Circuits, in two volumes, by Leonard Lane, [c 1961] Gernsback Library, Inc., 154 W. 14 St., New York 11, N. Y. 160 pp., each 8½", paperbound $3.20 per volume, both volumes $5.90, clothbound $9.90 for both volumes.

CIRCLE 226 ON READER-SERVICE CARD

How to Design and Specify Printed Circuits, Institute of Printed Circuits, 27 E. Monroe St., Chicago 3, Ill. 92 pp., 9", paperbound, $1.00.

CIRCLE 227 ON READER-SERVICE CARD

Basic Mathematics, Vol. 2, by Norman H. Crowhurst, [c 1961] John F. Rider Publisher, Inc., 116 W. 14 St., New York 11, N. Y. 144 pp., 9" paperbound, $3.90.

CIRCLE 228 ON READER-SERVICE CARD

Basics of Fractional Horsepower Motors and Repair by Gerald Schweitzer, [c 1960] John F. Rider Publisher, Inc., 116 W. 14 St., New York 11, N. Y. 176 pp., 9", paperbound, $3.90.

CIRCLE 229 ON READER-SERVICE CARD

Basic Carrier Telephony by David Talley, [c 1960] John F. Rider Publisher Inc., 116 W. 14 St., New York 11, N. Y. 176 pp., 9", paperbound, $4.25, clothbound $5.75.

CIRCLE 230 ON READER-SERVICE CARD

Basics of Missile Guidance and Space Techniques by Marvin Hobbs, Vol. 1, [c 1959] John F. Rider Publisher Inc., 116 W. 16 St., New York 11, N. Y. 304 pp., 9", paperbound, $3.90.

CIRCLE 231 ON READER-SERVICE CARD

Alternating Current Electricity, by Alexander Efron, [c 1961] John Rider Publisher Inc., 116 W. 14 St., New York 11, N. Y. 104 pp., 8½", paperbound, $2.25.

CIRCLE 232 ON READER-SERVICE CARD

Direct Current Electricity, Franklinian Approach, by Alexander Efron, [c 1960] John F. Rider Publisher, Inc., 116 W. 14 St., New York 11, N. Y. 100 pp., 8½", paperbound, $2.25.

CIRCLE 233 ON READER-SERVICE CARD

Advanced Magnetism and Electromagnetism, edited by Alexander Schure, [c 1959] John F. Rider Publisher, Inc., 116 W. 14 St., New York 11, N. Y. 104 pp., 8½", paperbound $2.25.

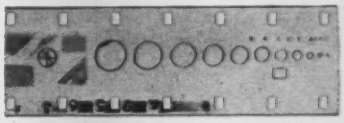
CIRCLE 234 ON READER-SERVICE CARD

Fundamentals of UHF by Allen Lytel, [c 1961] John F. Rider Publisher, Inc., 116 W. 14 St., New York 11, N. Y. 160 pp., 9", paperbound, $3.90.

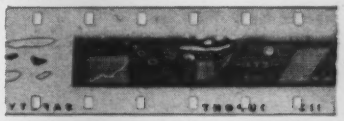
CIRCLE 235 ON READER-SERVICE CARD

NARROW-CHANNEL PHOTOGRAPHY

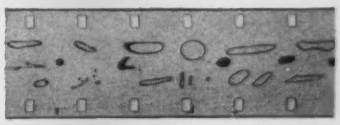
For people with the problem of photographing the interior of long, narrow channels, Kollmorgen has developed unusual devices capable of recording on film channels as narrow as 1/32 of an inch.



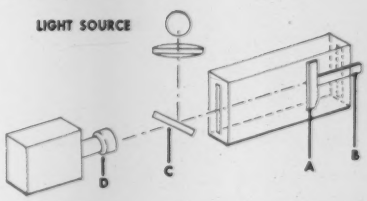
Above, actual size, is a test film of circles and numerals placed within a 1/32"-wide channel.



Above is a *panoramic* view of a continuous section of the same film . . . with marks enlarged 8x.



Pitting, corrosion, fracture and other defects of interior walls can be continuously recorded with full-dimensional accuracy . . . of exceptional value in quality control operations.



The secret of our insight: A highly precise 45° mirror (A), mounted on a reed (B), is inserted in one end of the channel. A beam splitter (C) directs a powerful light into the channel from the opposite end which is reflected by the mirror onto the sidewall. The photographic leg of the system receives the image from the channel mirror and through the beam splitter. A camera objective (D) focuses the image on the film. The channel is advanced by a carriage in precise synchronization with the advance of film. Result: a continuous, clear photographic record of the entire channel.

Various modifications of this device have been applied to channels up to six feet long. For longer and wider channels we have designed a miniature self-propelled camera, mirror and light source capable of presenting a continuous image on film with resolution sufficient to reveal scratches and hair-line cracks smaller than .010 inch.

If you need special insight on "inaccessible" interiors, or information on other unusual applications of optics/electronics/mechanics—let's talk it over.

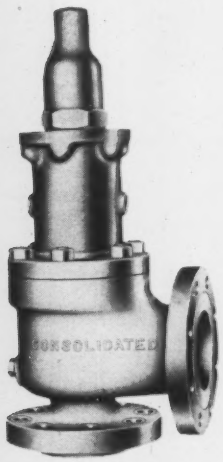
Write Dept. 12-11

KOLLMORGEN CORPORATION
NORTHAMPTON, MASSACHUSETTS

CIRCLE 20 ON READER-SERVICE CARD

top

CONSOLIDATED SAFETY RELIEF VALVES have a special "O" Ring Seat Seal that stops leakage completely



Consolidated Safety Relief Valves are available in both Standard and Balanced Bellows design for extreme corrosive applications.

tightness

The Seal is a resilient ring set in the valve disc. It maintains no-leak tightness by contact with a specially curved seating surface on the valve nozzle, yet does not carry the seat load imposed by the valve spring.

Tightness is maintained at operating pressures far closer to set pressure than with metal-to-metal seats alone. Tight closure is as efficient after "simmer" as on normal blowdown. Piping strains are absorbed far better by the resilient seal than all-metal seating. If the tough seal is ruined by entrained abrasives, replacement is easy. Seals are available in materials that resist corrosive fluids. Maintenance costs are greatly reduced.

Standard Consolidated Safety Relief Valves have an eductor tube that removes pressure from the closed bonnet. Only the spring controls valve action. You get guaranteed capacity ratings and highest dependability—absolute protection for personnel and equipment. Additionally, there is the economy of converting the Standard valve to the Balanced Bellows type in your own shop. Get complete details. Write for Bulletin 1940.

MANNING MAXWELL & MOORE INC. TRADE MARK

CONSOLIDATED SAFETY RELIEF VALVES

A product of

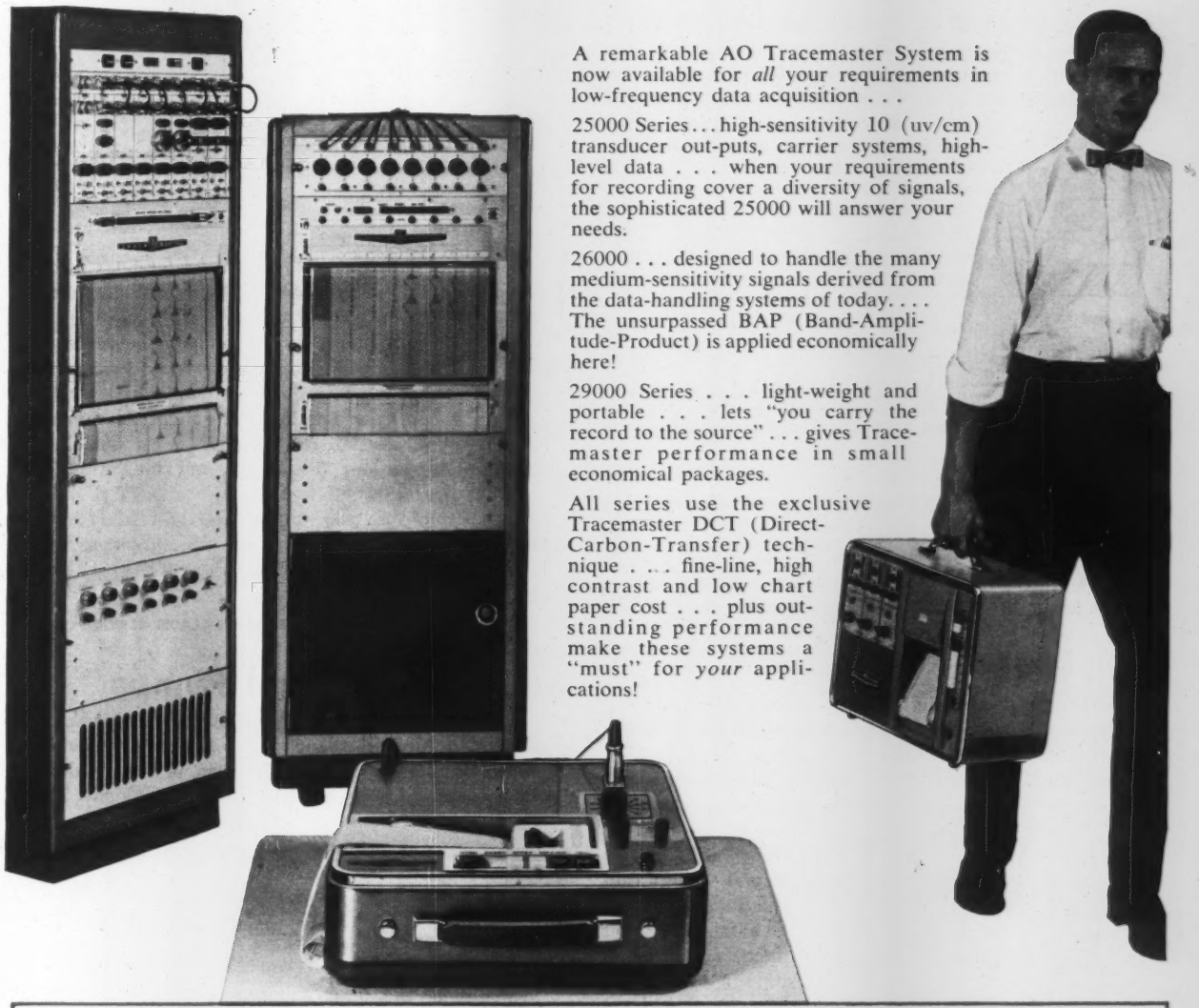
MANNING, MAXWELL & MOORE, INC.

Valve Division • Tulsa, Oklahoma

Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

CIRCLE 21 ON READER-SERVICE CARD

NOW...Versatility and Portability in the AO Tracemaster Systems!



A remarkable AO Tracemaster System is now available for *all* your requirements in low-frequency data acquisition . . .

25000 Series... high-sensitivity 10 (uv/cm) transducer out-puts, carrier systems, high-level data . . . when your requirements for recording cover a diversity of signals, the sophisticated 25000 will answer your needs.

26000 . . . designed to handle the many medium-sensitivity signals derived from the data-handling systems of today. . . . The unsurpassed BAP (Band-Amplitude-Product) is applied economically here!

29000 Series . . . light-weight and portable . . . lets "you carry the record to the source" . . . gives Tracemaster performance in small economical packages.

All series use the exclusive Tracemaster DCT (Direct-Carbon-Transfer) technique . . . . fine-line, high contrast and low chart paper cost . . . plus outstanding performance make these systems a "must" for *your* applications!

	25000 Series Tracemaster 8-channel, Floor-mounted Rack Cabinet	26000 Series Tracemaster 8-channel, Floor-mounted Rack Cabinet	29000 Series Tracemaster model 29100 Single-channel; Portable	29000 Series Tracemaster model 29300 3-channel; Portable
FREQUENCY RESPONSE	DC to 110 cps. ± 1% at 40 mm. peak to peak. Down 3 db at 140 cps.	DC to 100 cps. ± 5% at 40 mm. peak to peak. Down 3 db at 125 cps.	DC to 90 cps. ± 5% at 30 mm. peak to peak. Down 3 db at 125 cps.	DC to 90 cps. ± 5% at 30 mm. peak to peak. Down 3 db at 125 cps.
BAND AMPLITUDE PRODUCT	5600 (i.e. 40 mm. x 140 cps.)	5000 (i.e. 40 mm. x 125 cps.)	3750 (i.e. 30 mm. x 125 cps.)	3750 (i.e. 30 mm. x 125 cps.)
SENSITIVITY RANGE	10 Microvolts to 100 v/cm	100 mv/cm to 20 v/cm	50 mv/cm to 50 v/cm	50 mv/cm to 50 v/cm
CHART SPEEDS	0.1 to 500 mm/sec.	1 to 250 mm/sec.	1 to 200 mm/sec; or 5,50 mm/sec.	1 to 100 mm/sec.
CHART CAPACITY	1000 ft. roll	1000 ft. roll	200 ft. roll	200 ft. roll
WEIGHT			18 lbs.	40 lbs.

Just Write for Complete Information

American Optical COMPANY

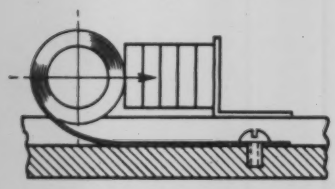
INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

CIRCLE 22 ON READER-SERVICE CARD

BRIEFS

Constant Force Springs

"Spring Design Data" briefly describes a type of coiled-band spring which differs from all other conventional springs by providing constant force at all deflections. This device (NEG'ATOR® Spring), is a prestressed strip of flat spring stock which coils tightly around a bushing or around successive layers of itself . . . Like the conventional spring, the constant-force spring stores energy by being forcibly stretched from a "relaxed" position. When permitted to release this energy, the constant-force spring recoils around its bushing and exerts a pull in doing so. To provide a means of attachment, the free end of the constant-force spring can be straightened or looped, blanked and punched . . . A variation of cavity mounting is the rolling action unit illustrated. Here the coil is free to move and, in its coiling and uncoiling action, pushes against a movable member.

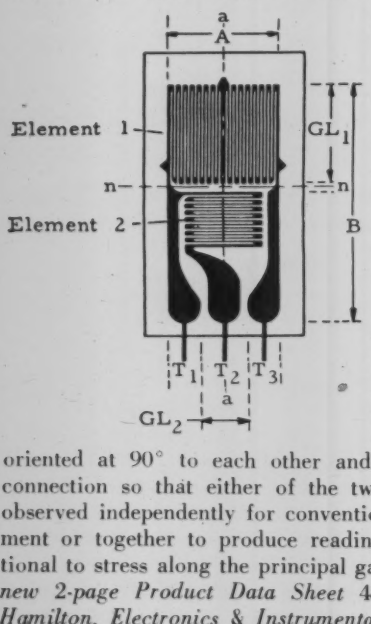


. . . (*From new* 12-*page "Spring Design Data," Hunter Spring Co., Lansdale, Pa.*)

FOR THIS LITERATURE CIRCLE 236 ON READER-SERVICE CARD

Stress-Strain Gage

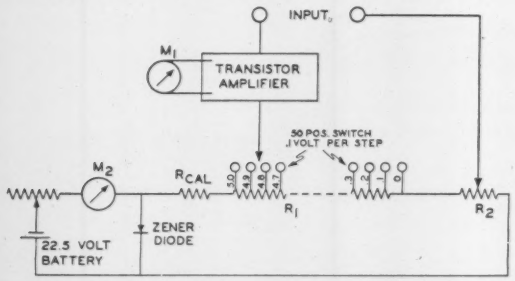
The BLH Stress-Strain Gage is a unique SR-4® bonded resistance foil type strain gage with electrical response proportional to either stress or strain at the discretion of the user. This "stress" measuring gage may be regarded as an automatic computer which solves the general stress-strain equations, rejects the axial component of strain due to stress in a transverse direction and responds only to that component of strain produced by stress in the axial directions . . . The gage is designed with two single axial strain sensing elements oriented at 90° to each other and having a common connection so that either of the two elements may be observed independently for conventional strain measurement or together to produce readings that are proportional to stress along the principal gage axis. . . . (*From new* 2-*page Product Data Sheet* 4323, *Baldwin-Lima-Hamilton, Electronics & Instrumentation Div., Waltham* 54, *Mass.*)



FOR THIS LITERATURE CIRCLE 237 ON READER-SERVICE CARD

Miniaturized Potentiometer

The Model PC POCKETPOT is a .05% accurate, miniaturized DC Potentiometer for use as an infinite impedance calibrator and measuring instrument . . . It is a completely self-contained high accuracy potentiometer

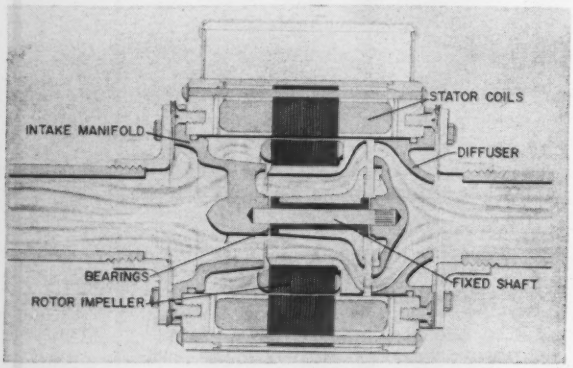


with internal galvanometer, standard reference source and direct "in line" dial readout . . . As in all potentiometers, a current is standardized through a chain of resistors, R_1 and R_2, to provide a known voltage drop across them, which is compared by a high sensitivity detector to the external voltage . . . In order to provide a high sensitivity null detector in a very small space, a tiny transistor amplifier has been used in this instrument to feed a small rugged indicator for the actual null indications. This detector gives a sensitivity well in excess of .1 millivolt, which is ample for the ranges involved . . . (*From new* 4-*page Publication "Electrical Measurements," Vol.* 28/*No.* 7, *Sensitive Research Instrument Corp.,* 310 *Main St., New Rochelle, N. Y.*)

FOR THIS LITERATURE CIRCLE 238 ON READER-SERVICE CARD

Centrifugal Pumps

The leakproof CORLEY Canned Sealess pump is the simplest, most versatile centrifugal pump available. Its only moving part, the rotor-impeller, is directly driven—not mechanically by a shaft but magnetically like an



electric motor . . . While physically isolating the pumped fluid from the stator, the sleeve magnetically acts like an air gap in an ordinary electric motor. It causes no measureable interference with magnetic flux . . .

The pumped fluid lubricates and cools the pump; hence the pump is not only without seals and stuffing boxes but it has no lubrication fittings to leak . . . (*From new* 4-*page Bulletin M*60, *Corley Co., Inc.,* 685 *Myrtle Ave. Boonton, N. J.*)

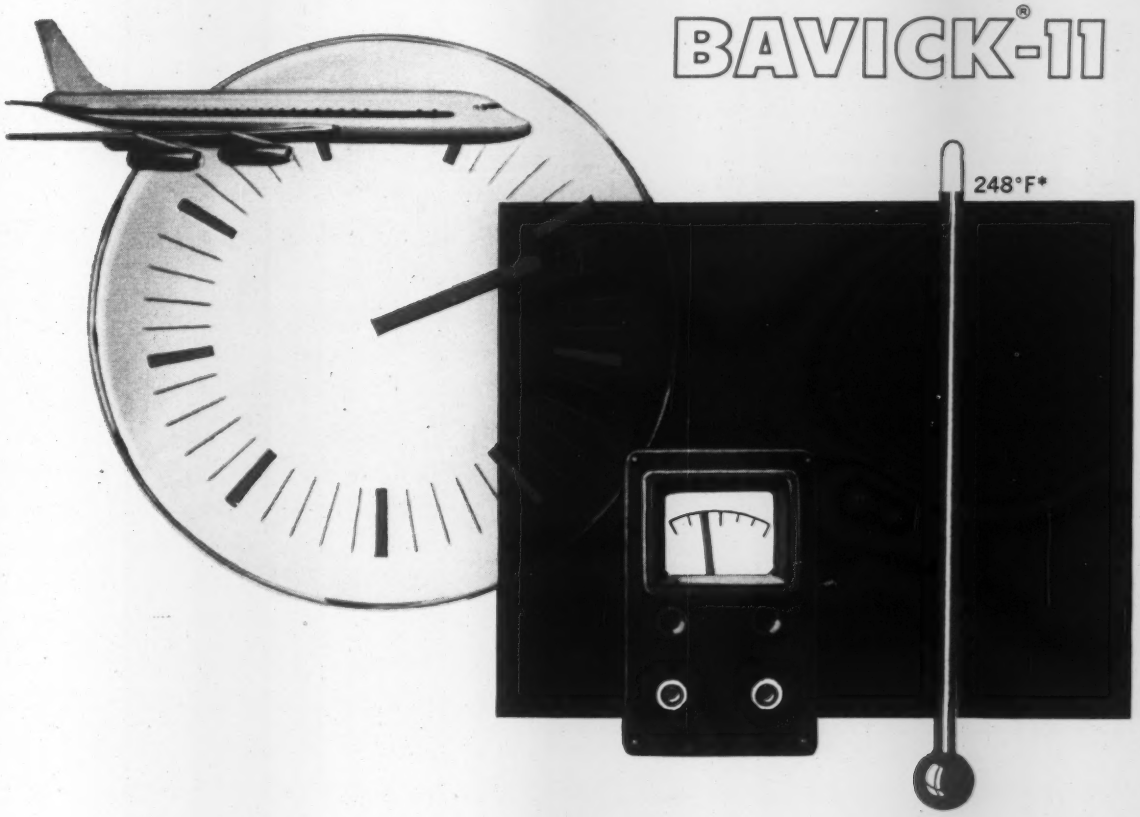
FOR THIS LITERATURE CIRCLE 239 ON READER-SERVICE CARD

Continued on page 1992

Highest heat resistance

of any water-white transparent thermoplastic

BAVICK®-11



Ideal for dial faces and windows, pointers, indicator lights, etc.

Bavick-11 is the *first* and *only* acrylic-type thermoplastic to offer the unique combination of properties described below. Bavick-11 is being used in important military instrument applications.

1. HIGH HEAT RESISTANCE. No warping or distortion at temperatures up to 248°F. No crazing or loss of transparency from extreme thermal shock.

2. SOLVENT / CHEMICAL RESISTANCE. No crazing or loss of transparency in chemical atmospheres—unaffected by most acids and alkalies, alcohols, silicones and aliphatic hydrocarbons.

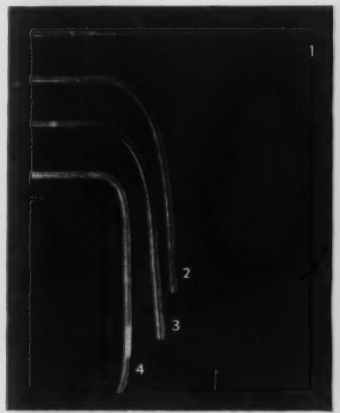
3. UNUSUAL OPTICAL PROPERTIES. Water-white clarity and high index of refraction. Ideal for "piping" light, edge lighting, etc.

4. RESISTS BREAKAGE. Strong, tough—resists mechanical shock.

5. EXTREME WATER / STEAM RESISTANCE. Transparency unaffected by continuous immersion in boiling water. Shape characteristics unaffected by steam at 5 p.s.i. pressure.

Bavick-11 is particularly valuable for aircraft, military, laboratory and electronic instruments. Dial faces and windows are crystal clear, strong, and withstand extremely high temperatures. Bavick-11 "pipes" light through dial pointers, is easily colored for indicator lights, and resists shock. Bavick-11 can be injection or compression molded, extruded, machined, cemented, and decorated.

These properties make Bavick-11 ideal for many other uses . . . in home appliances, automotive lighting, optical lenses, etc.



Effect of temperature on straight extruded rod at 240°F. for 72 hours. All rods clamped horizontally at one end.

1. BAVICK-11
2. Commercial Styrene-Acrylonitrile
3. Commercial Methylmethacrylate
4. Commercial Methylstyrene-Acrylonitrile

May we send you literature about new, heat-resistant Bavick-11? Write on your letterhead to Dept. ICS.

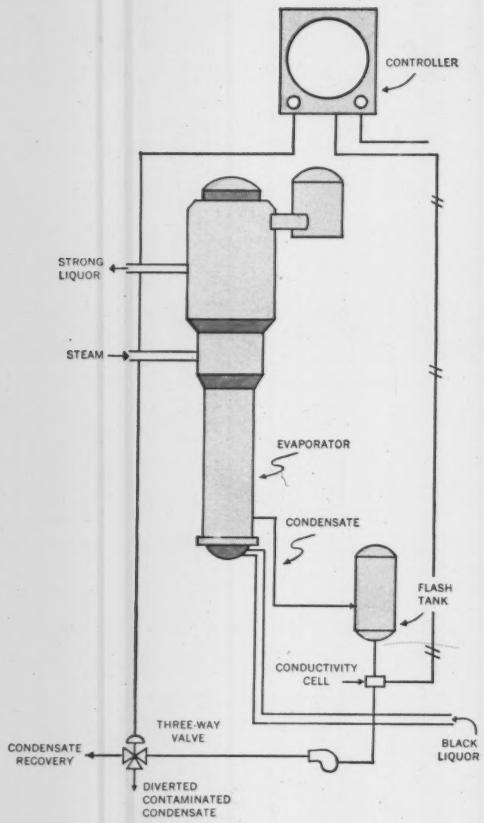
Plastic Division **J. T. Baker Chemical Co.**
Phillipsburg, New Jersey

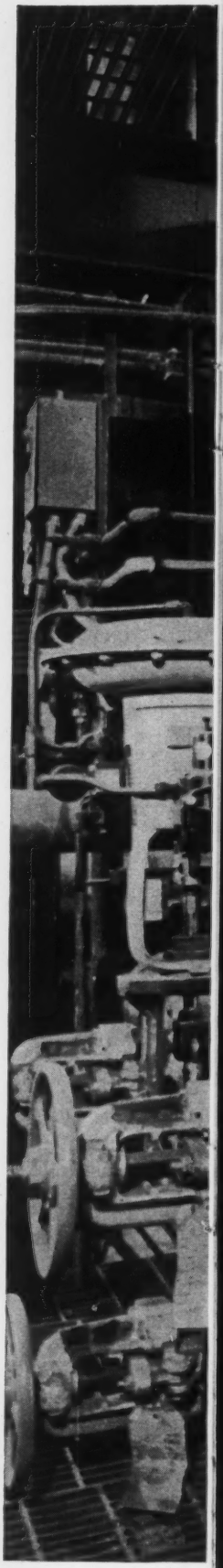
J.T.Baker CHEMICAL

®Registered Trademark *ASTM Heat Distortion D648 264 psi

CIRCLE 39 ON READER-SERVICE CARD

The Honeywell Three-Way Diverting Valve shown on the opposite page safeguards plant equipment at St. Regis Paper Company in Tacoma, Washington. Located in the steam condensate line leading from the multi-effect black liquor evaporator, the valve protects vital boiler tubes and pipes by diverting contaminated condensate. Contamination resulting from the presence of black liquor in the condensate is detected by a conductivity cell. When the concentration passes safe limits, a Honeywell *ElectroniK 15* Controller signals the valve to divert the contaminated condensate.





Protect plant equipment and reduce down-time with...

HONEYWELL THREE-WAY DIVERTING VALVES

Honeywell Three-Way Diverting Valves help protect vital plant equipment by diverting contaminated fluids to bypass, discharge or recirculating lines.

A Honeywell valve control system—consisting of a detecting element, a controller and a diverting valve—can provide simple, automatic protection for your plant equipment. A small investment in a Honeywell system of this type will help you keep your process equipment in top operating condition . . . materially reducing maintenance and down-time.

Other Honeywell valve control systems to keep temperature, pressure, level, pH and other process variables under strict control are also available.

The dependable performance and continuous protection afforded by these valves are the result of Honeywell's proven design, careful workmanship and broad process control know-how. *Every* aspect of valve performance is considered in relation to the overall control system. It is this "whole picture" approach that sets Honeywell control valves apart, and rewards you with reduced maintenance and more reliable operation.

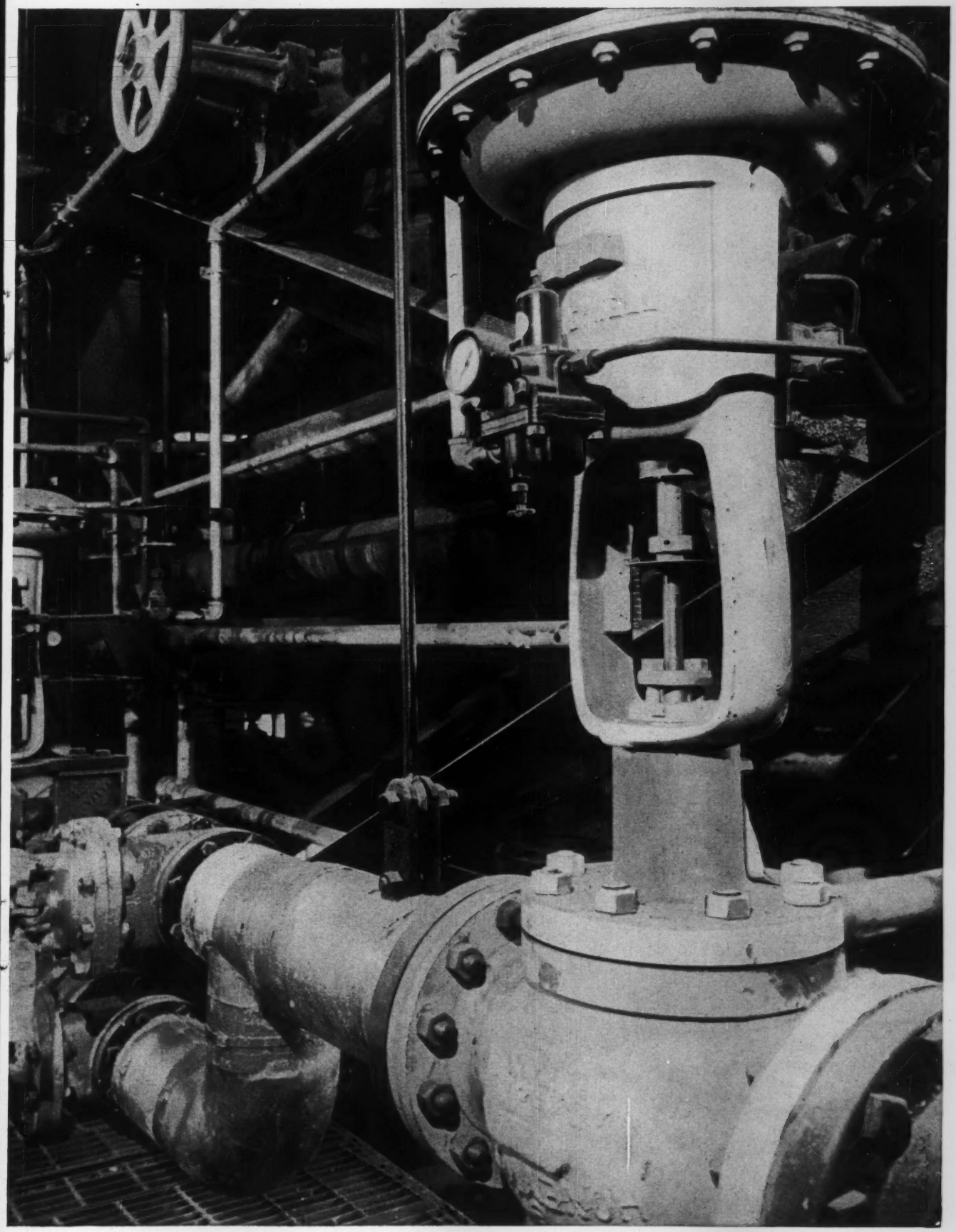
Write today for information on "Three-Way Valves" and their application.
MINNEAPOLIS-HONEYWELL, Fort Washington, Pennsylvania.

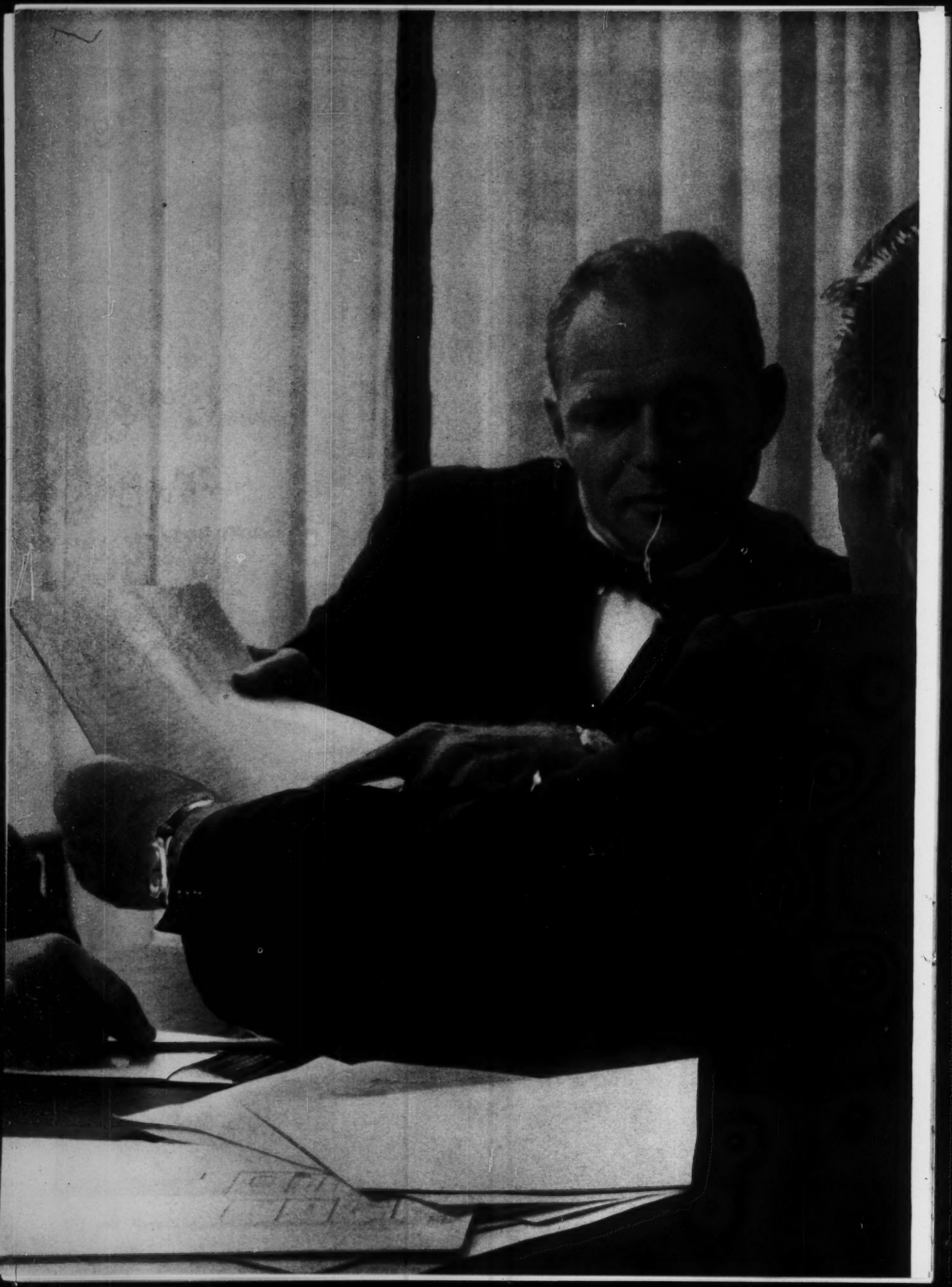
Honeywell

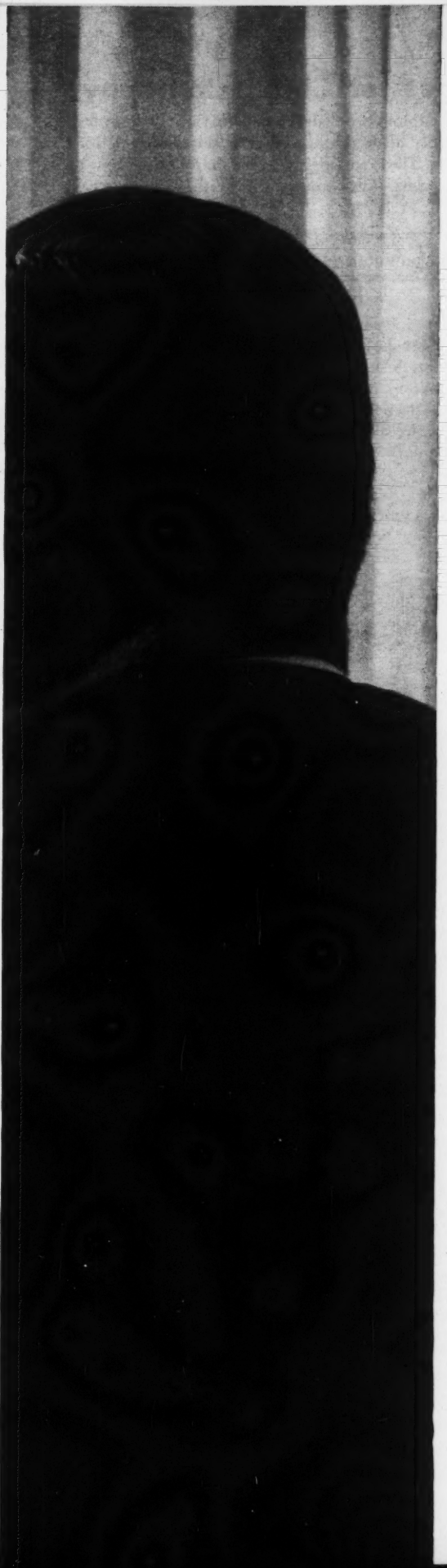
H HONEYWELL *First in Control*

HONEYWELL INTERNATIONAL Sales and Service offices in principal cities of the world.
Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

CIRCLE 24 ON READER-SERVICE CARD







"Bob, the computer analysis says we should buy those parts instead of making them"

NEW CAPITAL INVESTMENT PROGRAM

Here's a new IBM computer program that's yours for the asking. Using the Investors Method (Rate of Return on Investment), it helps you evaluate—*quickly, economically, uniformly*—alternate proposals for spending your company's money.

The program will help you solve problems like these: should you buy a new piece of equipment or keep the old one in repair; should you increase your manufacturing facilities; should you buy or make certain products; how should you spend your money for research to make the most profit?

These are only a few of the problems that the Capital Investment Program handles. All it takes is the Program and an IBM computer that accepts FORTRAN programming language. The low cost IBM 1620 Data Processing System is one such computer.

The new Capital Investment Program is another of the many problem solving programs IBM offers you to help make your data processing system a more effective and more profitable tool for managing your business.

Your local IBM Representative can give you complete details on this, as well as previously announced programs, which included Sales Forecasting, Materials Planning, Inventory Management, Plant Scheduling, Work Dispatching, Operations Evaluation, Inventory Management Simulation, and many others.

IBM®
DATA PROCESSING

CIRCLE 25 ON READER-SERVICE CARD

DIALCO® PILOT LIGHTS

with Built-in Resistor
(a patented DIALCO feature)
for the Neon Glow Lamp NE-51H (High Brightness)

RUGGED: The NE-51H Neon Glow Lamp is made to resist vibration and is proof against sudden failure. It may be operated at about 3 times the level of current applied to the standard neon lamp, and it will produce 8 times as much light—*with long life!* Requires low power—less than 1 watt on 250 V circuit. Recommended for AC service (may be used on DC circuits above 160 V).

BUILT-IN current-limiting resistor (U.S. Patent No. 2,421,321): For use on 105-125 volt and 210-250 volt circuits. In DIALCO Pilot Lights, the built-in resistor is completely insulated in moulded phenolic and sealed in metal.

COMPACT: Units are available for mounting in 9/16" and 11/16" clearance holes...in a wide choice of lens styles and colors, terminal types, metal finishes, etc. Meet applicable MIL Spec and UL and CSA requirements.

Every assembly is available complete with lamp.

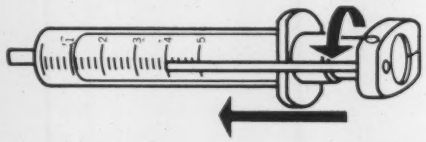
SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Ask for Bulletin No. 100 and Catalogue L-161B.

Foremost Manufacturer of Pilot Lights
DIALIGHT CORPORATION
42 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600
CIRCLE 26 ON READER-SERVICE CARD

Syringes for Chromatography

Chaney Adaptors were developed to rapidly deliver a precise quantity of liquid throughout a series of injections or deliveries. They easily give repeatability of 1% or better with semi-skilled operators. With careful work,

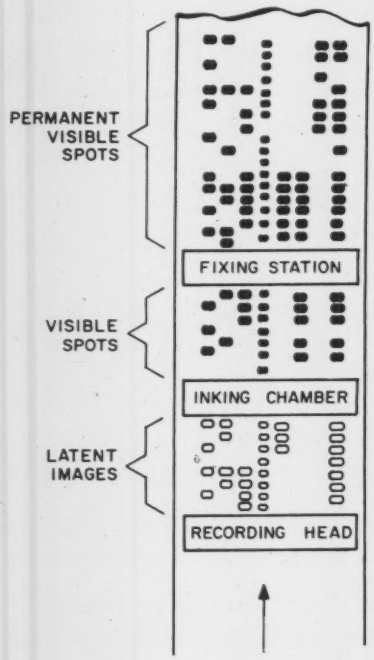


repeatability can be 0.1%. These syringes with adaptors are ideal when chromatography is used for plant control, in the laboratory pipetting of standard solutions for routine analysis, or making a series of standard volume injections . . . (*From new brochure "Precision Measurement Equipment for Chromatography, Radiochemistry, Radiomedicine," Hamilton Co., Inc., Box 307, Whittier, Calif.*)

FOR THIS LITERATURE CIRCLE 240 ON READER-SERVICE CARD

Paper Tape

With the Omni-Data technique, information is stored on the surface of the paper and at no time does the reading or recording head touch the tape. The result is a no-impact, no-contact highly flexible system . . .



The Omni-Data Recorder accepts standard data pulses (—12 volts for a mark and sprocket, 0 volts for a space) and records them as visible spots in the same code configuration as punched tape . . . The Omni-Data Reader uses the principle of chopped, reflected light to interpret spots or holes in the tape . . . Diagram illustrates the electrostatic recording technique. The tape used is a high resistivity plastic coated paper tape with a conductive backing . . .

(Pulsing) electrodes . . . cause a discharge, charging the surface of the paper through ion migration from the discharge cloud to the surface of the tape with the migration confined to a precise shape and area. A latent image in the form of the electrostatic charge is on the surface of the tape. The image is made visible by passing the tape through a bath of dry powdered ink which adheres to the charge area . . . (*From new 8-page News Release, Omnitronics, Inc., Subs. of Borg-Warner, 511 N. Broad St., Phila., Pa.*)

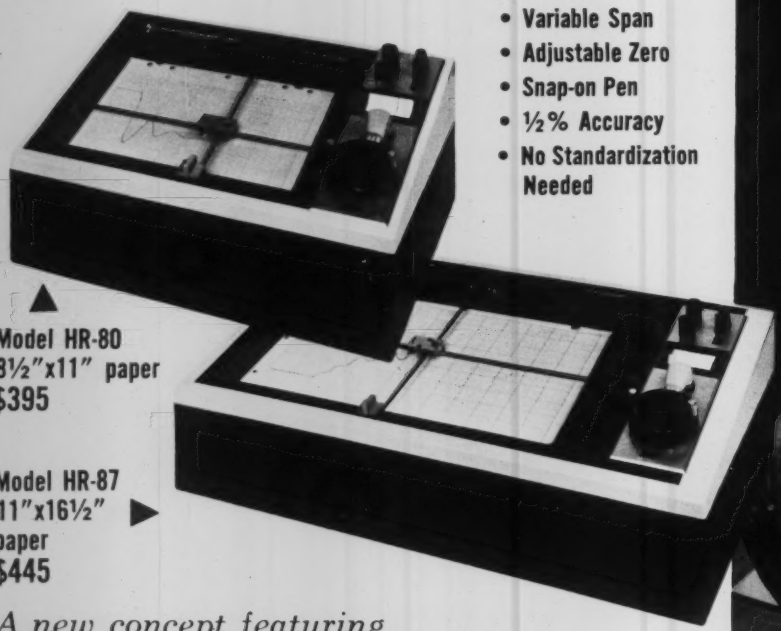
FOR THIS LITERATURE CIRCLE 241 ON READER-SERVICE CARD

Continued on page 1998

CIRCLE 27 ON READER-SERVICE CARD→

WHY HASN'T SOMEONE DONE THIS BEFORE?

T-Y* moving pen RECORDERS



- Variable Span
- Adjustable Zero
- Snap-on Pen
- ½% Accuracy
- No Standardization Needed

Model HR-80
8½"x11" paper
$395

Model HR-87
11"x16½" paper
$445

A new concept featuring maximum convenience in rectilinear recording of any variable as a function of time

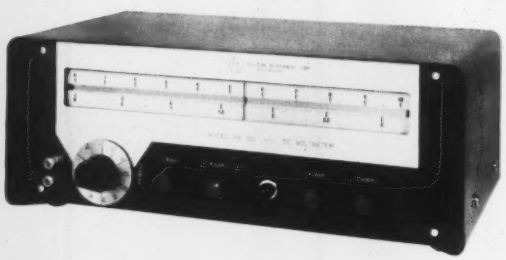
The T-Y recorder is designed to replace conventional self-balancing strip chart or circular chart recorders in any laboratory or industrial application where a total chart length of either 10" or 15" will provide adequate resolution. Records from the T-Y recorder are immediately available for use or reproduction and will fit standard laboratory notebooks or files. The inconveniences of handling and cutting chart rolls and of re-plotting data are eliminated. The T-Y recorder operates from low level DC signals. The inexpensive time motors are plug-in and are available for any required record time. A manual return lever and slip-clutch permit many records to be made and compared on one chart.

Why hasn't someone done this before?
Done what?
Offered a sensibly priced recorder for plotting any variation as a function of time on standard graph paper

*Trade Mark

SELF BALANCING POTENTIOMETRIC DC VOLTMETER

INPUT IMPEDANCE: OVER 1000 MEGOHMS
ACCURACY: 0.2%



- **MULTIRANGE SELECTION** 11 ranges from 0-3 mv to 0-300 volts
- **ZENER REFERENCE** eliminates standardization
- **14 inch MIRROR SCALE** allows precise reading at a distance
- **UNIVERSAL CASE DESIGN** converts from rack to case in minutes

Model HV-160
POTENTIOMETRIC
DC VOLTMETER
$545

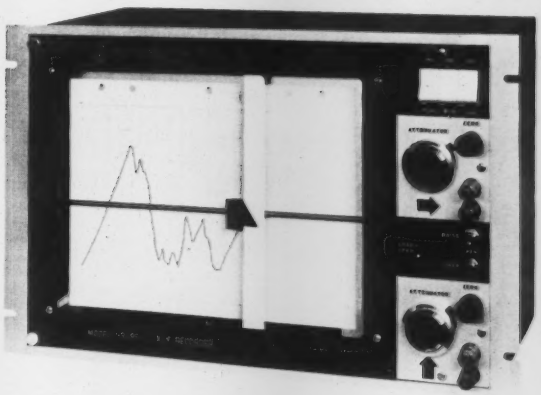
Instruments for automatically recording any variable vs. any other variable on linear or logarithmic scales

X-Y
RECORDERS
and converters

for automatically recording

any variable vs. any other variable on

linear or logarithmic scales



APPLICATIONS

- Stress/strain, temperature/pressure, etc.
- Semi-conductor and tube characteristics
- Bio-medical data
- Any slowly varying phenomena for which a permanent record is desired

WITH CONVERTERS

- DB vs. log frequency audio response plotting
- Filter and servo dynamic performance curves
- AC signals

SEE CONVERTERS ON NEXT PAGE

NEW
MODEL HR-95R
rack mounting

$875

Mail card below for data
on other rack and bench models

- **VACUUM PAPER HOLDDOWN**
- **10 TURN PRECISION ATTENUATORS**
- **SNAP-ON CARTRIDGE PEN ASSEMBLY**
- **ZENER REFERENCE SUPPLY (OPTIONAL)**

Please send complete technical information on the following items by return mail:

- ☐ **T-Y RECORDERS**
- ☐ **X-Y RECORDERS**
- ☐ **DC POTENTIOMETRIC VOLTMETER**
- ☐ **70 DB LOG VOLTMETER-CONVERTER**
- ☐ **LOG FREQUENCY CONVERTER**
- ☐ **AC/DC CONVERTER-VOLTMETER**

Name: _____ Co.: _____

Dept.: _____ Address: _____

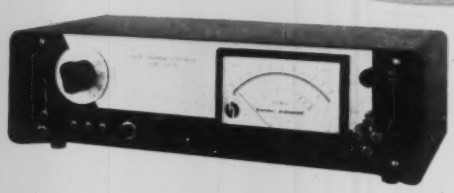
City: _____ Zone: _____ State: _____

SOMETHING REALLY NEW IN AC MEASUREMENT AND CONVERSION / *Linear* / *Log Amplitude* / *Log Frequency*

70 DB Continuous scale!
Provides precise log amplitude for log vs log frequency X-Y plotting. When used as an AC or DC voltmeter, a moveable DB scale eliminates adding or subtracting reference level. Accuracy better than 0.2 DB throughout 70 DB range.

$1450

MODEL HLVC-150
LOG VOLTMETER
AND CONVERTER



MODEL HVC-30 AC/DC CONVERTER-VOLTMETER

$775

Fast Ripple Free Response, 5 cps to 100 KC!
Truly general purpose combination instrument designed to handle signals at very low levels and low frequencies and to operate satisfactorily with X-Y recorders digital voltmeters, strip chart recorders, potentiometric precision voltmeters or separately as a 1% AC VTVM. 10 ranges from 10 MV to 300V full scale.

MODEL HLFC-120 LOG FREQUENCY CONVERTER

$580

Provides precise log frequency for automatic response plotting!
Permits precise plotting of response vs log frequency with any laboratory oscillator over 5 cps to 20 kc range without switching. DC output ~ log of input frequency at accuracy levels previously unattainable.

FIRST CLASS
Permit No. 9329
HOUSTON, TEXAS

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POSTAGE WILL BE PAID BY

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MOhawk 7-7403 CABLE: HOINCO
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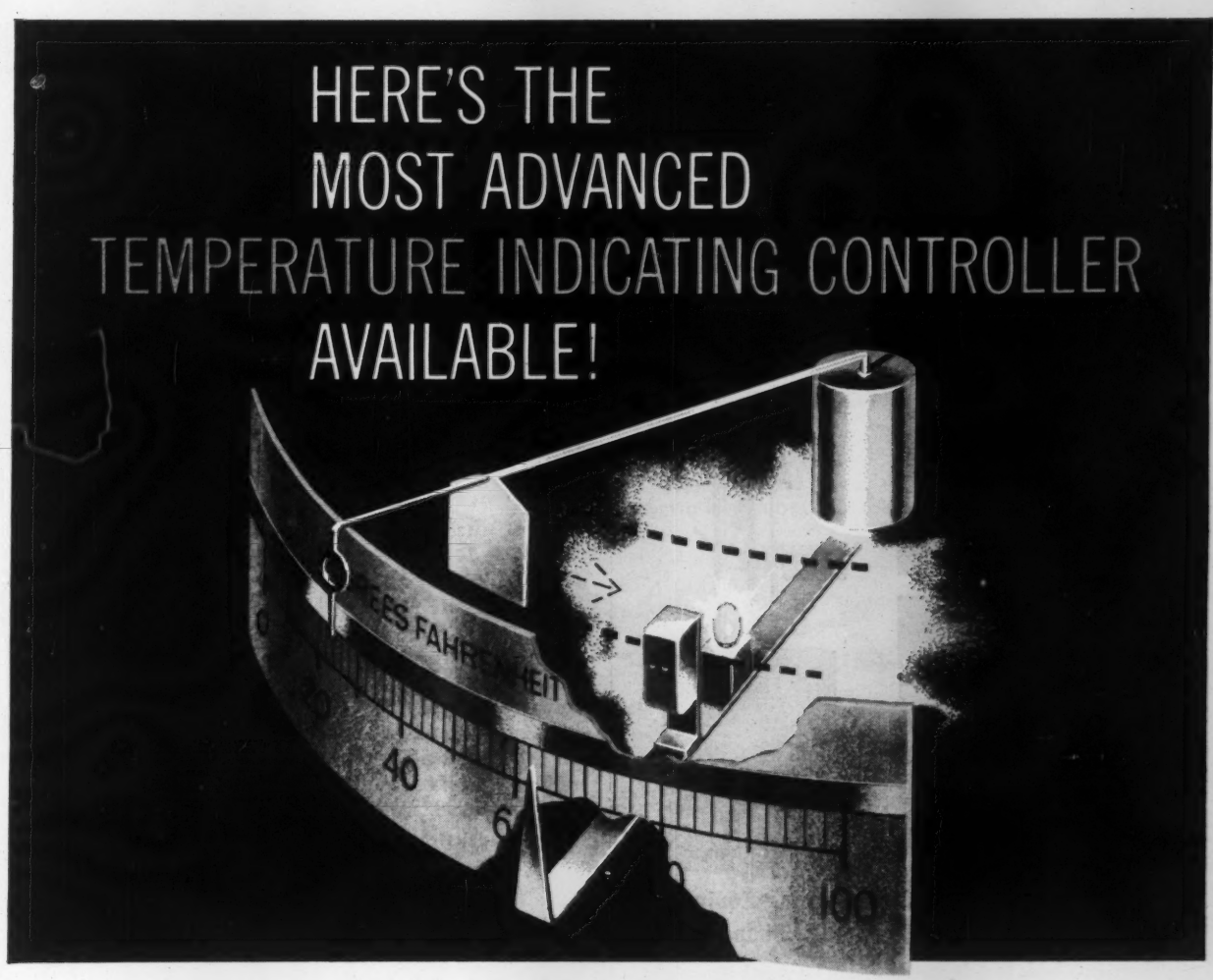
LITHO IN U.S.A.

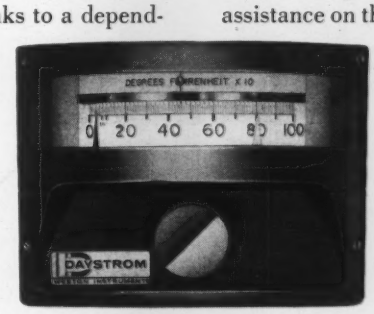
HERE'S THE MOST ADVANCED TEMPERATURE INDICATING CONTROLLER AVAILABLE!



NEW SENSITROL PYROMETER COMBINES

- **Daystrom Creative Engineering**
- **Weston Accuracy and Reliability**

The Daystrom Sensitrol Pyrometer is now available for your *most critical* temperature control applications. This new instrument has an accuracy of ±0.5%, full scale, and a sensitivity of ±0.1%, thanks to a dependable Weston galvanometer sensing element. A non-contact photocell actuates the control . . . completely eliminating drag on the galvanometer.



Here are a few of the many other features offered by Model 8800 Sensitrol Pyrometer: Solid state throughout. Plug-in modular construction for simplicity of maintenance . . . no soldering required. Only 10$\frac{3}{16}$" x 7$\frac{1}{2}$", the unit can be flush or panel mounted. It has a long 6-inch scale, range of 0-400 to 0-4,000 F, with set points adjustable over entire range. Signal lights at each end of the scale make it easy to read control position from a distance. Two modes—ON-OFF or three position.

Write today for complete technical data or applications assistance on the new Sensitrol Pyrometer—a product of unexcelled Daystrom experience and traditional Weston accuracy! Daystrom, Incorporated, Weston Instruments Division, 229 Manchester Road, Poughkeepsie, N. Y.

International Sales Division, 100 Empire St., Newark 12, N. J. In Canada: Daystrom Ltd., 1480 Dundas Highway East, Cooksville, Ontario.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Reliability by Design

CIRCLE 38 ON READER-SERVICE CARD

GET *IMMEDIATE* ANSWERS WITH

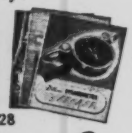
YOUR OWN **Dillon** TESTING DEPARTMENT!

PROFESSIONAL Testing Equipment Within Reach of the Average Shop Budget!

Your own *available* test department can be worth its weight in gold. In addition to getting *immediate* answers to your problems, you'll save outside fees...and costly employee waiting time.

Whatever your product, there's a Dillon instrument you can use to advantage. Tensile, compression, torque or shear ...1 pound to *1 million* pounds! Anyone can operate. Rugged and dependable. Guaranteed accuracy!

PLEASE BE SURE TO MENTION PRODUCT IN WHICH YOU ARE *SPECIFICALLY* INTERESTED. A COPY OF OUR *GENERAL* CATALOG ON *OTHER* DILLON PRODUCTS WILL BE INCLUDED.



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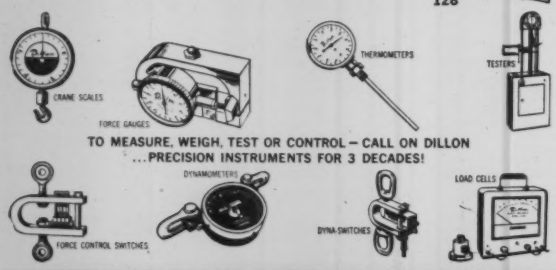


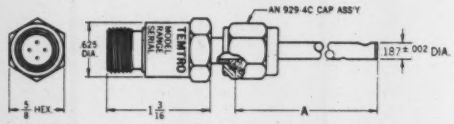
TO MEASURE, WEIGH, TEST OR CONTROL – CALL ON DILLON ...PRECISION INSTRUMENTS FOR 3 DECADES!

W. C. **Dillon** & COMPANY, INC.

Dept. 113, 14584 Keswick Street, Van Nuys 81, California
Representatives in All Principal Cities
CIRCLE 29 ON READER-SERVICE CARD

Temperature Transducers

TEMTRO probes are small, rugged, sensitive, and extremely accurate. With integral one-piece stainless-steel construction, they are highly resistant to physical and thermal shock. They can operate in practically any en-



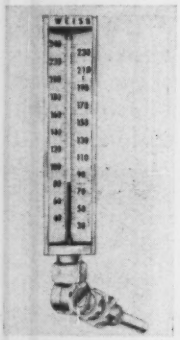
vironment, in practically any medium, with guaranteed accuracy of 1/10% of full range from —452° to 1750°F. Response is fast, linearity high, hystersis almost nonexistent . . .

Although platinum for years has been the recognized world standard, TEMTRO specializes in tungsten elements for these reasons: In cryogenic ranges, tungsten resolution is dramatically greater (in cryogenic liquid level sensing, where platinum has a short life or is a catalyst —with H_2O_2, for example—tungsten is ideal). In the intermediate ranges, tungsten best satisfies the need for a high-resolution high-accuracy element for probes and surface sensors. Tungsten is excellent for ocean temperature sensing in ASW systems, where, again, extremely high accuracy and resolution are critical. For nuclear applications, tungsten displays superior qualities in high-radiation fields . . . (*From new* 4-*page brochure, Temtro, Inc.,* 3016-*C S. Halladay, Santa Ana, Calif.*)

FOR THIS LITERATURE CIRCLE 242 ON READER-SERVICE CARD

Industrial Thermometer

Accuracy of a thermometer is composed of two characteristics: (1) That which is apparent to the observer at a particular instant; (2) that which is intrinsic to the instrument. Apparent accuracy can readily be measured. Intrinsic accuracy is the hidden qualities built into a thermometer, and for all practical purposes evaluated only by experience or laboratory testing . . .



Weiss engineers have developed and improved an easily adjustable, universal type case angle. VARI-ANGLE® is quickly and easily adjustable to any angle for maximum visibility before, during. or after installation. The VARI-ANGLE Thermometer can be specified for most any requirement where unusual angles are needed and hard to fit positions are found . . . Our VARI-ANGLE connection totally encloses the sensitive portion of the thermometer glass tube and glass sealing capillary alloy. Dirt and other foreign matter cannot enter or become trapped in the instrument . . . (*From new* 16-*page Catalog* 260, *Albert A. Weiss & Son, Inc.,* 263 *Vanderbilt Ave., Brooklyn* 5, *N. Y.*)

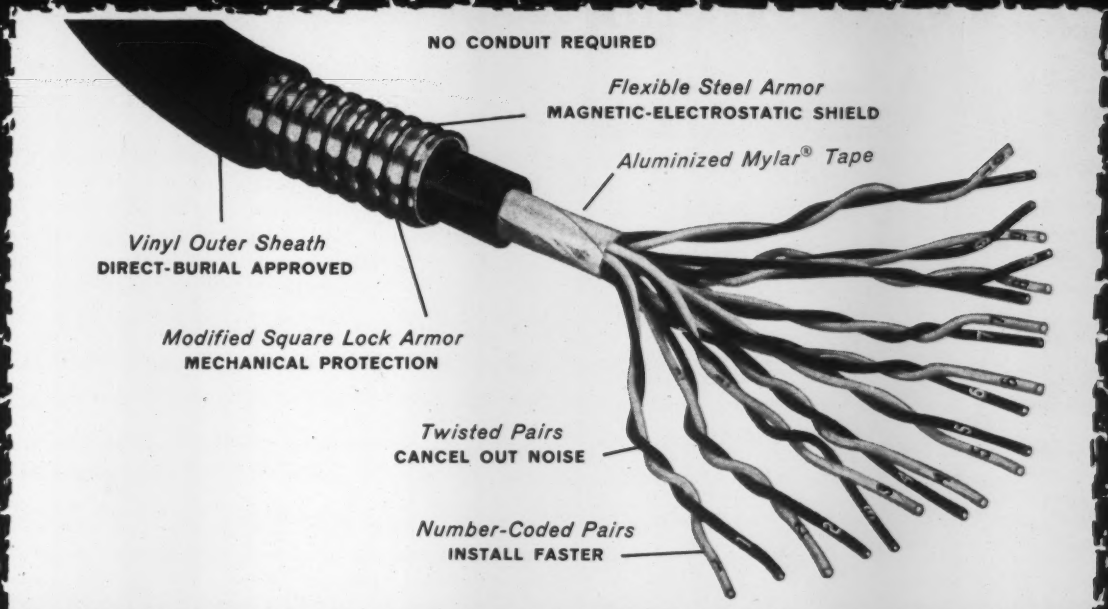
FOR THIS LITERATURE CIRCLE 243 ON READER-SERVICE CARD

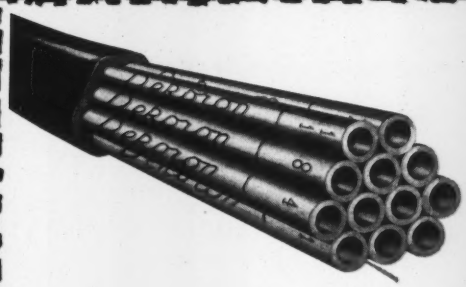
Continued on page 2000

CIRCLE 30 ON READER-SERVICE CARD→

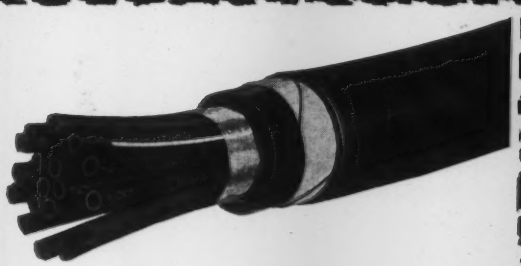
DEKORON TYPE "AT" MULTICOUPLE EXTENSION WIRE WITH MAGNETIC SHIELD *keeps your process up to par years longer.*

Other advantages of Dekoron Type AT include easier installation . . . greater resistance to crushing, chemical and moisture attack for lowest maintenance. Always specify Dekoron products for maximum performance with minimized cost.





Dekoron New Metl-Cor combines exclusive parallel tubes of copper or aluminum with polyethylene protective sheath. Lack of "corkscrew effect" speeds installation. Dekoron also offers a full line of metal-armored tubing harnesses.



Dekoron Protecto-Pac (Type FB shown), an all-plastic harness with high resistance to weld splash, sparks, flash fires, etc. Dekoron Poly-Cor (not shown) has number-coded polyethylene tubes, Mylar® vapor barrier, flexible vinyl outer sheath.

Dekoron® products

quality • research • service

A-4298-A

SAMUEL MOORE & COMPANY • DEKORON PRODUCTS DIVISION • **MANTUA, OHIO**

FREE SOLENOID VALVE DATA!...from VALCOR

"HOW TO SPECIFY SOLENOID VALVES", an 8-page brochure complete with drawings, diagrams, charts and curves.

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Both are free. Both should be at your fingertips.

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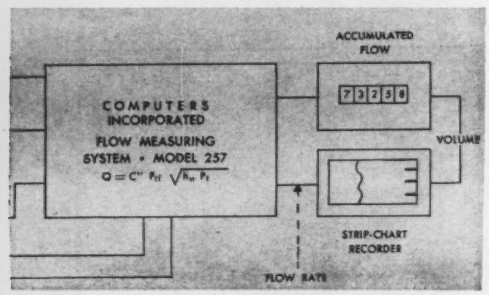
VALCOR ENGINEERING CORP.

5366 Carnegie Avenue, Kenilworth, N. J. • CH 5-1665

CIRCLE 31 ON READER-SERVICE CARD

Electronic Flow Measuring System

Flow Measuring System Model 257 performs two primary functions: (1) Measures the flow rate and accumulated volume of fluid passing through an orifice plate under conditions ranging from steady to intermittent



flow. (2) Provides signals proportional to these quantities for operation of automatic flow control equipment, and remote control recording equipment.

Transducers measure static and differential pressures, and flowing temperatures, and send electrical signals to the computer. The computer then combines these signals in solving the flow equation . . .

The flow coefficient, "C", is inserted into the computation by means of a plug-in adapter unit and is a product of the following factors:

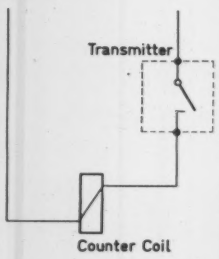
Basic Orifice Factor; Reynolds Number Factor; Expansion Factor; Pressure Base Factor; Temperature Base Factor; Specific Gravity Factor; Supercompressibility Factor . . .

The Computer Flow Rate is supplied to a magnetic integrator which gives an electrical pulse for a preselected increment of volume, in standard cubic feet. This pulse is then used to operate a mechanical counter to give a visual indication of accumulated volume . . . (*From new 4-page bulletin, Computers Inc., 5123 Glenmont Dr., Houston 36, Texas.*)

FOR THIS LITERATURE CIRCLE 244 ON READER-SERVICE CARD

Impulse Transmitters

Mechanically actuated transmitters transform motion into electrical counting impulses. The mechanical motion creates a pulse of 40 ms duration, which is independent of speed or character of motion . . . In motor driven transmitters the contact is actuated through energization of a synchronous motor. Impulse output is proportional to time. The reliability of an impulse counting system is dependent, primarily, on two components: (1) the impulse counter and (2) the impulse transmitter (or generator) . . . (*From new 4-page bulletin "Sodeco Impulse Transmitters," Landis & Gyr, Inc., 45 West 45th St., New York 36, N. Y.*)



FOR THIS LITERATURE CIRCLE 245 ON READER-SERVICE CARD

Continued on page 2002

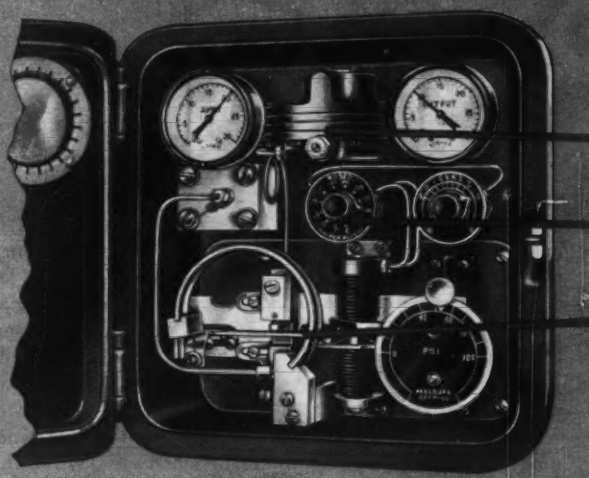
How to get ACCURATE PRESSURE CONTROL IN SPITE OF DEMAND CHANGES

ask your **FISHER/MAN** about the

WIZARD II

PRESSURE CONTROLLER

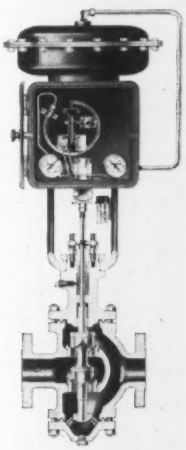
with new and improved features



1. **VOLUME RELAY** for faster response to pressure changes.
2. **RESET FEATURE** for greater stability and pin-point control, adjustable from .005 to 1 minute per repeat.
3. **MEASURING ELEMENT** may be brass, steel or stainless steel Bourdon tubes for pressures from 30 to 15,000 psi or Bellows assemblies for pressures below 30 psi and vacuum.

WIZARD I

PRESSURE CONTROLLER



The original Wizard I Pressure Controller is still available for those applications not requiring volume relay or reset features. The simplicity of a self-operated regulator and the accuracy of a pilot or relay operated regulator are found in the Series 4100U. This is, unquestionably, the reason for the continued popularity of the Wizard I series.

As for all Wizards, the Series 4100U is furnished with a universal case which enables the unit to be flush or surface mounted or mounted on yoke of a control valve. Measuring Elements: Bourdon Tube—Bronze, Steel or St. Steel—Ranges 25 to 7,500 psi. Bronze or St. Steel Bellows for vacuum to 25 psi.

The Wizard II has been designed to specifically meet the demands of modern, complex systems requiring closer and faster control. The Wizard II retains the basic simplicity and dependability of the Wizard 4100U, plus more speed and accuracy.

The new design consists of two sub-assemblies encased in a weather proof die cast aluminum housing which is provided with a ¼" pipe threaded vent. Either sub-assembly can be removed without disturbing case mounting. The simple but effective proportional band adjustment (2 to 100%) and the reset adjustment (.005 to 1 min/repeat) along with ease of reversing the action of the Wizard II, have contributed much to its popularity in process control work. All Wizard II controllers, with exception of differential models, can be supplied with a process or controlled pressure gauge installed inside the case.

Careful and exhaustive tests and years of field use have conclusively proved that the Wizard II measures up to rigid Fisher standards.

A COMPLETELY DESCRIPTIVE AND ILLUSTRATED BULLETIN ON THE WIZARD II IS YOURS FOR THE ASKING. WRITE FOR BULLETIN No. D-4150B OR BULLETIN D4100 ON WIZARD I.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD...CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / Rochester, England

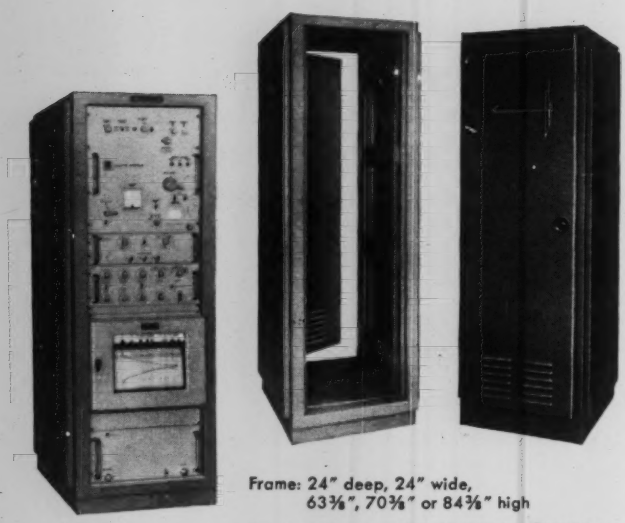
BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIP. CO., CORAOPOLIS, PA.

FISHER® Controls

SINCE 1880

CIRCLE 32 ON READER-SERVICE CARD

"PACKAGED" PROTECTION FOR YOUR CONTROLS



Frame: 24" deep, 24" wide,
63⅜", 70⅜" or 84⅜" high

Front panel space: 56", 63", 70" or 77" high

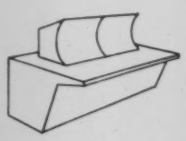
New Honeywell Modu-Mount* Cabinets

Now you can get standard enclosures to protect your valuable precision instruments and devices. New Honeywell Modu-Mount Cabinets are designed by experts to provide the ultimate in appearance, convenience and economy. Best of all, you can order them to fit your specific enclosure requirements.

The rugged steel frame can be left open or enclosed by panels and doors. You can specify such features as anti-tilt mobile base, wiring trough, lift-bars and eyebolts, or floor levellers, vibration mounting and cooling louvers. And up to five Modu-Mount Cabinets can be supplied with a common base and wiring trough.

Modu-Mount Cabinets come in standard green, grey or brown baked enamel. Other colors are available at your request. For details, call your nearby Honeywell office. Or write Honeywell, Dept. IC-11-61, Minneapolis 8, Minnesota. *Sales and service offices in all principal cities of the world.*

HONEYWELL CUSTOM ENCLOSURES



Honeywell will design and custom-build any cubicle, panel, console or other enclosure to your exact specifications. Special attention is given to these orders, and the finished product meets the most stringent requirements.

Honeywell

First in Control

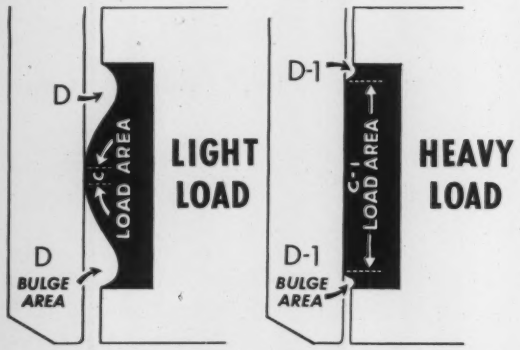
SINCE 1885

CIRCLE 33 ON READER-SERVICE CARD

Knife Gate Valves

The valve is bonnetless; the gate—not the stem—moves through the packing . . .

The DeZurik Ring-Seal Seat consists of a stainless steel ring with a resilient compound, formed to a special shape,



bonded to each face in an annular groove . . . Although it resembles one, the Ring-Seal Seat is NOT an "O" ring. It operates on a "shape factor" principle which can be described as the ratio of load area to the free normal bulge area . . . The Ring-Seal Seat is shown being subjected to a low pressure drop. The load area (C) is small; great sensitivity results because a small load area will deflect easily. The relatively large and unrestrained bulge area (D) also contributes to sensitivity. While this side of the Ring-Seal Seat is forming a dynamic seal with the gate, the other side (not shown) forms a static seal with the valve body. Under high pressure drop, the load area (C-1) has broadened and the bulge area (D-1) has been reduced. The seat now has tremendous ability to resist further deflection. The seat cannot be sheared off because relieved portions incorporated into the shape provide "protected" areas into which the seat can expand . . . (*From new 8-page Bulletin 302, DeZurik Corp., Sartell, Minn.*)

CIRCLE 246 ON READER-SERVICE CARD

Available—NOW

Volume Two (Circuits 101-200) of Aronson and Kezer's

100 ELECTRONIC CIRCUITS

A continuation of the well-received Volume 1, this later edition covers new ground including circuits for power supplies, oscillators, instruments, amplifiers, phototube and pulse applications. Also gives complete data on telemeters, controllers and alarms. Paper, 212 pages, 1960. Price only $2 per copy.

Instruments Publishing Co., Inc., 845 Ridge Ave., Pittsburgh 12, Pa.

Enclosed is $——for—copies Vol. 2—100 Electronic Circuits.*

Name .....

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*Also enclosed is $——for——copies (at $2 each) Vol. 1—Electronic Circuits.

NEW

SOLID-STATE ANNUNCIATORS BY EDISON

IN MODULAR UNITS OF UNEQUALLED RELIABILITY AND COMPACTNESS

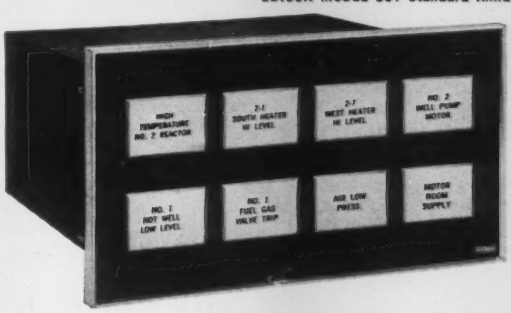
With a revolutionary concept in annunciator design, Edison is the first to offer both conventional and miniaturized systems, **fully transistorized** in compatible cabinets for either console or panel mounting. Each annunciator circuit, including lamps and light box, is completely contained in a miniaturized channel-mounted plug-in module—a unique Edison development. The modules are entirely without moving parts, and maximum reliability and exceptionally long life are further ensured by derating of all components.

In addition to 4- and 8-point cabinets with miniature ¾″ by 1½″ nameplates, Edison's new line of transistorized annunciators also includes 4- through 48-point cabinets with standard 2″ by 3″ nameplates. The miniaturized 4- and 8-point systems are ideal for consoles or graphic panels where space is limited. Each of the readily interchangeable plug-in modules is engineered for the widest practicable range of applications, and for the utmost in thermal and mechanical ruggedness. And the basic modular design is calculated to facilitate growth in step with the increasing sophistication of your operating system.

For complete technical data — and for information on how the new Edison annunciators combine the ultimate in protection with a dramatic reduction in over-all size — ask your Edison Representative or write for Catalog 3060.

EDISON MODEL 360 Miniature Annunciators

EDISON MODEL 361 Standard Annunciators


HIGH TEMPERATURE NO. 2 REACTOR
2-1 SOUTH HEATER HI LEVEL
2-1 WEST HEATER HI LEVEL
NO. 2 SHELL PUMP MOTOR
NO. 1 HOT WELL LOW LEVEL
NO. 1 FUEL GAS VALVE TRIP
AIR LOW PRESS.
MOTOR ROOM SUPPLY

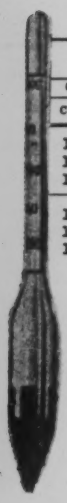
Thomas A. Edison Industries

INSTRUMENT DIVISION

41 LAKESIDE AVENUE, WEST ORANGE, N. J.

CIRCLE 34 ON READER-SERVICE CARD

Hydrometers



SPECIFIC GRAVITY

LENGTH		CALIBRATION TEMPERATURE	LENGTH	
6 in.	150 mm	60/60°F	12 in.	300 mm
CATALOG NO	DIV.	STOCK RANGE	DIV.	CATALOG NO
1000	.002	0.600–0.700	.001	1180
1010	.002	0.700–0.800	.001	1190
1020	.002	0.800–0.900	.001	1200
1030	.002	0.900–1.000	.001	1210
1040	.002	1.000–1.100	.001	1220
1050	.002	1.100–1.200	.001	1230

General Testing

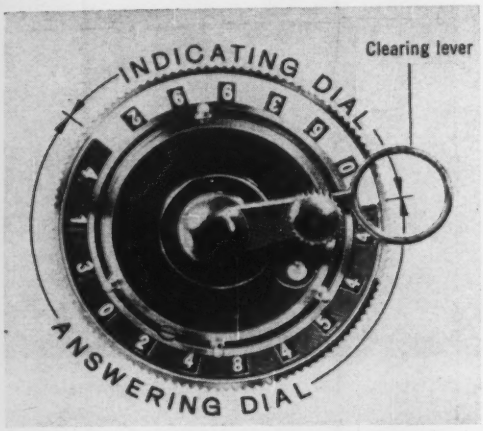
Cordials, Liquors, Commercial Alcohols Precision Grade	Length: 11 in.	
15 to 35%	2/10% Proof	3410
30 to 50%	2/10% Proof	3420
45 to 65%	2/10% Proof	3430
60 to 80%	2/10% Proof	3440
75 to 95%	2/10% Proof	3160
90 to 110%	2/10% Proof	3170
105% to 125%	2/10% Proof	3450
130 to 140%	2/10% Proof	3460
135 to 155%	2/10% Proof	3470
150 to 170%	2/10% Proof	3480
165 to 185%	2/10% Proof	3490
180 to 200%	2/10% Proof	3500

(From new 8-page Catalog 1000, E. Griebel Co., Carbondale, Pa.)

CIRCLE 247 ON READER-SERVICE CARD

Mini Calculating Machine

Curta is a complete pocket size calculating machine for all four arithmetical operations . . . It adds, subtracts, multiplies, divides, squares, cubes, extracts square roots . . .



The handling of the machine is similar to that of ordinary large machines, except that it is held in one hand, preferably in the left, with thumb and forefinger gripping the knurled edge of the carriage . . . *(From new 64-page pocketsize handbook containing formulas and arithmetical rules, Curta Co., 14436 Sherman Way, Van Nuys, Calif.)*

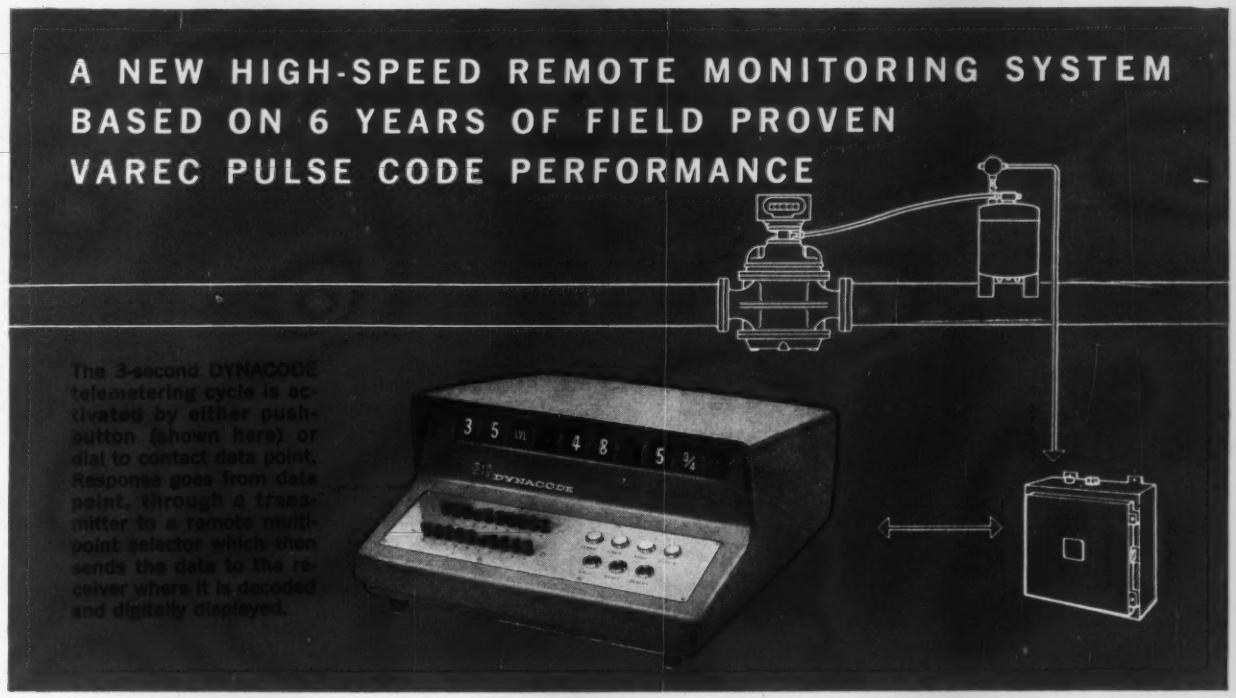
CIRCLE 248 ON READER-SERVICE CARD

Continued on page 2006

CIRCLE 35 ON READER-SERVICE CARD

DYNEL DYNACODE TELEMETERING SYSTEM

A NEW HIGH-SPEED REMOTE MONITORING SYSTEM BASED ON 6 YEARS OF FIELD PROVEN VAREC PULSE CODE PERFORMANCE



The 3-second DYNACODE telemetering cycle is activated by either push-button (shown here) or dial to contact data point. Response goes from data point, through a transmitter to a remote multi-point selector which then sends the data to the receiver where it is decoded and digitally displayed.

Dynel engineers—utilizing the performance proved concepts of Varec's famous Pulse Code system—have developed the significantly advanced DYNACODE telemetering system for remote readings of liquid level, temperature and P.D.M.

This single-channel, "error-proof" system combines the proven reliability of the basic Varec system with a digital readout time of 3 seconds per point...readout accuracy of 1/16 inch...readout capacity of an unlimited number of points...and readout versatility that permits the system to be tied into a general purpose computer for inventory, billing, and similar functions.

Solid state components are used at key points in the receiver design for longer, maintenance-free life. And DYNACODE, like Varec's Pulse Code, has an instantaneous alarm system without scanning delays.

The high-speed DYNACODE System offers these advantages:

Reliability: Design based on 6 years of performance in scores of pipeline and refinery applications.

Data Display: Illuminated, in-line digital display includes point and function identification, digital data to 6 significant figures and liquid level to 1/16" increments.

Fast Response: data from any given point is gathered and digitally displayed in just 3 seconds.

Flexibility: Designed on building block principle that permits a great variety of system arrangements...DYNACODE is compatible with all standard systems of measurement.

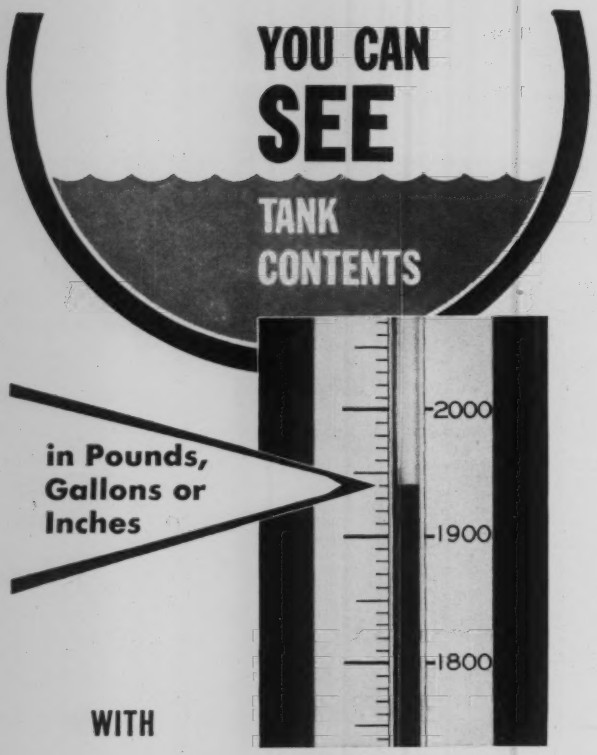
Readout Variety: digital output provides a variety of readouts, including visual display, paper tape, typewriter, etc. Output is compatible for use with general purpose computers.

For complete information, write for Bulletin 301, Dept. ICS-1600-3

DYNEL, Inc., *a subsidiary of Varec, Inc.*

12923 S. Spring Street, Los Angeles 61, California • Branches and Representatives in Principal Cities

CIRCLE 36 ON READER-SERVICE CARD



The King-Gage

With the King-Gage you *see at a glance* the weight, volume or depth of liquid in *any* storage or processing vessel—on the spot or hundreds of feet away—with none of the hazards, delays or uncertainties of measuring by stick or tape. *In man-hour savings alone, these gages often pay for themselves in 6 to 12 months.*

The King-Gage has the inherent accuracy of a U-tube—*works as a frictionless balance,* with no wearing parts. Its dependability has been proven by 33 years' service, in every industry and on ships of the U. S. Navy.

And LOCAL SERVICE is provided. There's a King-Gage distributor near you, factory-trained to give installation and maintenance service when you need it.

Thus, for measuring bulk liquids of *any* kind —to guard against shortages, errors in receipts and deliveries, losses in processing, and inaccuracy when charging tanks for formulating —it pays to use the King-Gage. CATALOG 1010 gives further facts and shows many applications. May we send you a copy?

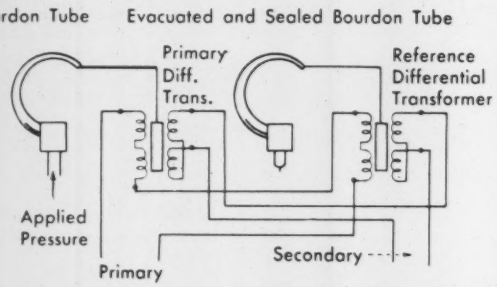
KING ENGINEERING CORP.
3205 S. State St. Ann Arbor, Mich.
LIQUID LEVEL GAGES, MANOMETERS, ACCESSORIES SINCE 1937

CIRCLE 37 ON READER-SERVICE CARD

Differential Transformers

A Differential Transformer is an electromechanical transducer that produces an AC voltage proportional to the displacement of its moving element from the electrical center.

The stationary element consists of a primary wire winding and a secondary wire winding on a cylindrical coil



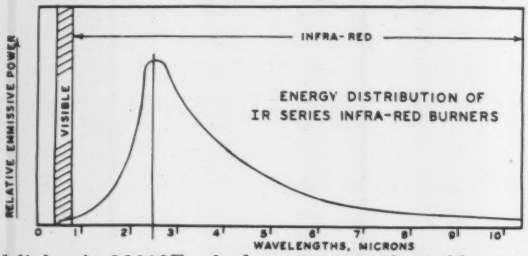
form enclosed in a protective shell. The two coils of the Atcotran primary winding are connected in series and energized by an alternating current power supply to provide a continuous magnetic field. The two coils of the secondary winding are connected in series so that their induced output voltages are 180 degrees out of phase (i.e. bucking). The position of the moving element—an armature of magentic material—determines the strength of the magentic field which induces the voltage into each coil of the secondary winding . . .

Differential Transformers . . . are used to transduce motion of bellows, diaphragms, bourdon tubes, . . . strains of all types (proving rings, springs), . . . into an electrical signal . . . (*From new* 12*-page Bulletin* 6208, *Automatic Timing & Controls, Inc., Subs. of American Manufacturing Co., Inc., King of Prussia, Pa.*)

FOR THIS LITERATURE CIRCLE 249 ON READER-SERVICE CARD

Infrared Burners

Infra-Red energy is electro-magnetic radiation, similar to radio waves, in the spectrum from the highest radar frequencies to visible light . . . At 600°F all radiation of a body is carried by wave lengths longer than visible

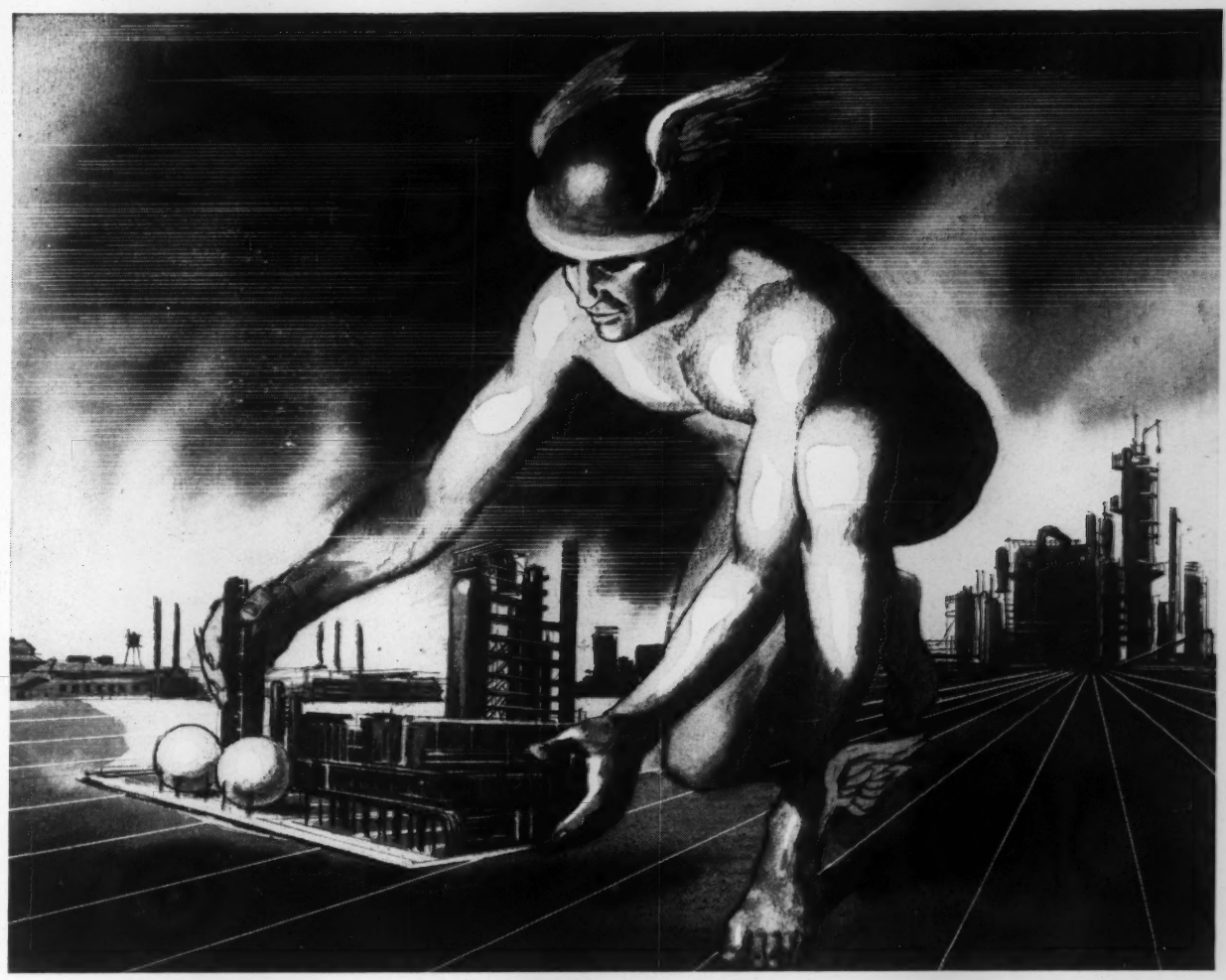


red light. At 1300°F a body emits enough visible energy to be self luminous and appears "red hot." . . . At 1600°F less than 0.05% of the total energy is in the visible range . . .

Infra-Red Burners will convert approximately 50% of their input energy into Infra-Red radiation. The balance of the input energy exists in hot flue gases. Drying operations particularly can use this additional convection energy to preheat, increase speeds and reduce heat losses from the work . . . (*From new* 2*-page Data Sheet ID*287, *Pyronics Inc.,* 17700 *Miles Ave., Cleveland* 28, *Ohio.*)

FOR THIS LITERATURE CIRCLE 250 ON READER-SERVICE CARD

Continued on page 2012



The Temperature Control Powered by the

IRREPRESSIBLE FORCE OF MERCURY–

for Accuracy with Rugged Dependability

All Partlow temperature controls are directly and positively actuated by mercury, the metal in liquid form whose reaction to changes in temperature is as predictable as it is powerful.

Unlike delicate electronic controllers, the mercury-actuated Partlow requires no outside power source. No amplifiers. No finicky levers. And no "babying"! With a Partlow you can be sure of getting accurate, dependable control even under extreme conditions of shock and vibration.

Mercury-actuation makes possible maximum design efficiency and simplicity too. The Partlow has fewer parts to go wrong. And fewer service problems (with less "down" time) should trouble occur. You can replace the thermal element of any Partlow control instantly, right at the job site, without recalibrating, fitting or factory adjustment.

Whatever the process or application, you'll find a Partlow temperature control to fit it dependably, economically, *precisely*. Mail coupon today for full details.

PARTLOW

TEMPERATURE CONTROLS

World Export:
Ad. Auriema, Inc., 85 Broad Street, New York 4, N. Y.

THE PARTLOW CORP., Dept. D-1161
NEW HARTFORD, N. Y.

Please send condensed Catalog of Partlow temperature controls and allied equipment for industrial heating and refrigeration.

Name and Title .....

Company .....

Address .....

City and State .....

.....

CIRCLE 68 ON READER-SERVICE CARD

Low Cost Cubic S-70 Data System Reads 100 Channels/Minute

Because of the high operating speed of the reed relays (used in the digital voltmeter) the new Cubic S-70 Data System gives readings 6 times faster than any others using stepping switch voltmeters. The Cubic S-70 monitors up to 100 separate channels, provides instantaneous large digital readout on the voltmeter, and prints out a permanent record on paper tape of 100 readings a minute. Yet it costs only $4650, a fraction of the cost of most data systems now in use. Price includes the Cubic V-70 Reed Relay Digital Voltmeter, the Cubic Scanner to rapidly sample 100 channels, and an 11-column printer. An ac-dc converter or a pre-amplifier may be added at slight additional cost. The reed relays in the voltmeter assure you of at least a decade of flawless service without periodic maintenance. This is a simple, pre-packaged, standard system made up of production modules. You simply plug it in and start recording data. For more details on the S-70 Data System, write to Department IC 110

cubic
CORPORATION
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SAN DIEGO 11, CALIFORNIA • ROME, ITALY

OTHER OFFICES: LOS ANGELES, CALIFORNIA—ROME, ITALY (CUBIC EUROPA S.p.A.) • REPRESENTATIVES IN PRINCIPAL U.S. AND CANADIAN CITIES

CIRCLE 15 ON READER-SERVICE CARD

Bourns Offers Total Transducer Capability

NUMBER 14 — INSTRUMENT SERIES

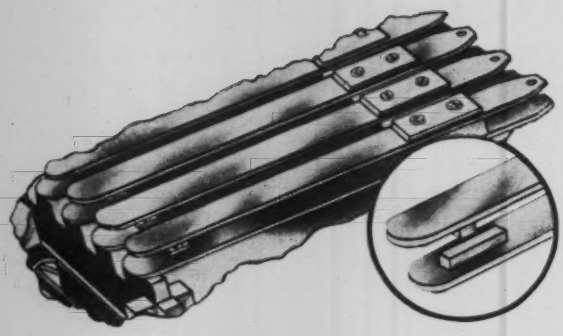
Bourns offers you the full spectrum of transducer capabilities—research, development, production, quality control and environmental testing. From concept to completion, Bourns maintains rigid surveillance over the manufacture of every part of every instrument.

Need transducers for position? Pressure? Acceleration? Bourns can fill your order for 10 units or 1000, each instrument conforming exactly to your requirements, each instrument delivered with a detailed certificate of inspection and calibration. Unusual problem? Bourns engineers, credited with many of the industry's most notable innovations, will provide a solution that meets your specs, your budget and your deadline—a solution backed by an 11-year record of reliability in virtually every major U. S. missile and space program.

Write for new instrument summary brochure.

Pioneers in transducers for position, pressure, acceleration. Exclusive designers and manufacturers of Trimpot® potentiometers

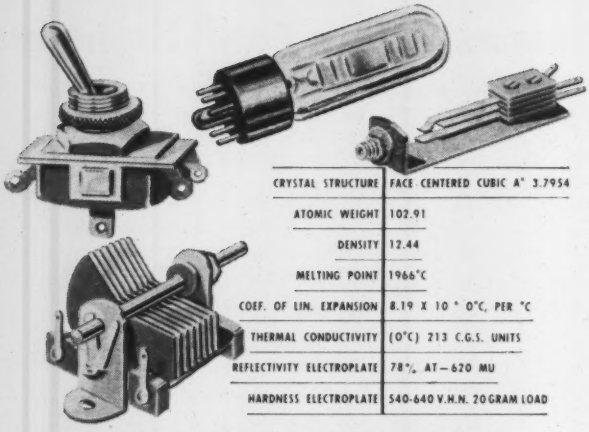
CIRCLE 40 ON READER-SERVICE CARD



ECONOTAPE CONTACTS ARE MOST EFFICIENT FOR ELECTRICAL RELAYS

High reliability welded contacts and contact assemblies available for your relays. Weld strength guaranteed. • Overall contact height held within ±.00025. Assemblies are available in gold, platinum, palladium, silver and their various alloys—both solid and laminated. Single contact usable for various contact ratings, for wet and dry circuitry—assemblies protected for shelf life and handling. Designs for attachment to header by welding or brazing. Complete electrical and mechanical design services available.

D. E. MAKEPEACE DIVISION
PINE & DUNHAM STREET • ATTLEBORO, MASS.

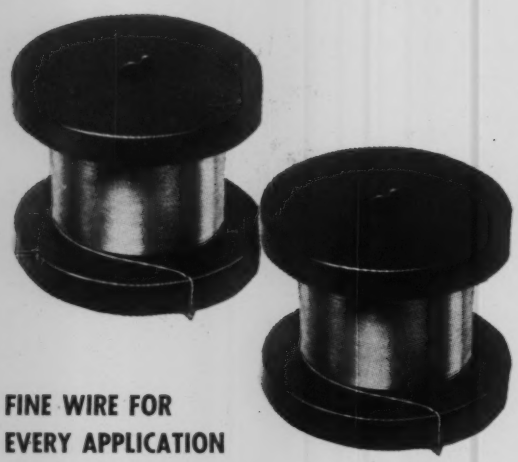


CRYSTAL STRUCTURE	FACE CENTERED CUBIC A° 3.7954
ATOMIC WEIGHT	102.91
DENSITY	12.44
MELTING POINT	1966°C
COEF. OF LIN. EXPANSION	8.19 X 10 ° 0°C. PER °C
THERMAL CONDUCTIVITY	(0°C) 213 C.G.S. UNITS
REFLECTIVITY ELECTROPLATE	78%, AT—620 MU
HARDNESS ELECTROPLATE	540-640 V.H.N. 20 GRAM LOAD

RHODIUM PLATING RESISTS CORROSION

Rhodium plating offers outstanding protection against surface corrosion under all atmospheric conditions. Used in electrical and electronic applications, it improves efficiency whenever a low-resistance, long-wearing, oxide-free component is required . . . assures low noise level for moving components . . . provides positive action for components subject to long periods of inactivity . . . eliminates partial rectification and unwanted signals by keeping components oxide-free. Send for complete technical data.

CHEMICAL DIVISION
113 ASTOR STREET • NEWARK, N. J.

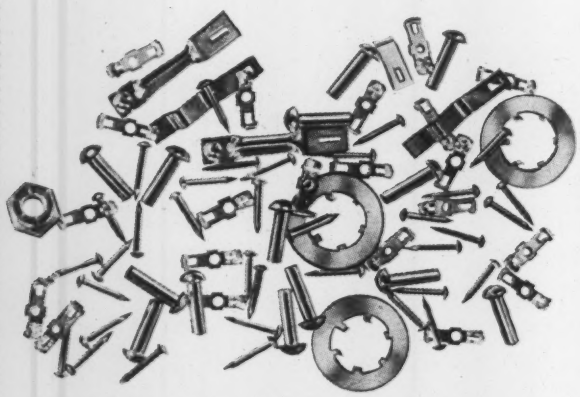


FINE WIRE FOR EVERY APPLICATION

A thoroughly dependable source for fine wire of ductile and non-ductile materials for every application. Special processes have been developed for bare drawing wire as fine as .0004". Wollaston Process for ductile metals . . . Taylor and extrusion methods for non- ductile metals are employed to meet requirements for finer wire. All standard fine wires are stocked for prompt delivery. Full facilities are available for production of fine wire made to customer's individual requirements. Write for details.

BAKER PLATINUM DIVISION
113 ASTOR STREET • NEWARK, N. J.

FOR WELDED CONTACTS CIRCLE 41 ON READER-SERVICE CARD
FOR FINE WIRE CIRCLE 42 ON READER-SERVICE CARD



SIMPLIFIED SILVER PLATING FOR ELECTRICAL AND ELECTRONIC COMPONENTS

The simplest, most efficient process for protecting electrical, electronic and lamp components with mirror-bright silver plating in flash to heavy deposits. Silva-Brite is a crystal-clear solution—work is visible during plating process. Plating is quick, easy, non-critical with results assured at current densities from 10 to 40 amps psf—and little or no polishing required. Normal room temperature operation minimizes fumes and bath decomposition. Write for complete information on Silva-Brite and application procedure.

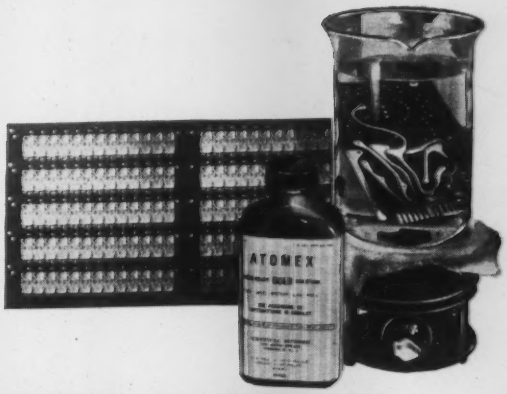
AMERICAN PLATINUM & SILVER DIVISION
231 N. J. RAILROAD AVENUE • NEWARK, N. J.

FOR RHODIUM PLATING CIRCLE 43 ON READER-SERVICE CARD
FOR SILVER PLATING CIRCLE 44 ON READER-SERVICE CARD

PLATINUM SPIRALS MEASURE TEMPERATURE BY ELECTRICAL RESISTANCE CHANGE

Precise electrical thermometer using platinum spirals provides temperature measurements within ± 1/10th of 1°C. Voltage signal varies with temperature for covering a range from −220°C to +500°C. The temperature transistor elements, sealed in hard glass thin wall tubes, provide fast time response. 25, 50 or 100 ohm units available as well as a selection of tube geometries. A similar group of platinum spirals are ceramic encased for measuring temperatures as high as 750°C with slightly less accuracy. Special laboratory standard precision electrical thermometers also available.

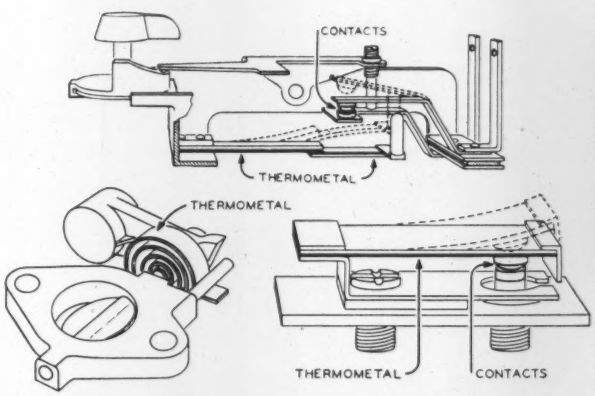
INDUSTRIAL EQUIPMENT DIVISION
INSTRUMENTS AND SYSTEMS SECTION
850 PASSAIC AVENUE • E. NEWARK, N. J.



IMMERSION GOLD COATING FOR ELECTRICAL AND ELECTRONIC PARTS

Use Atomex gold immersion solution for more permanent, less expensive coating of printed circuits, metallized plastics, etc. with complete assurance of tarnish resistance and electrical resistivity. In a simplified immersion process, 24K gold is deposited by ionic displacement in a thin, dense, uniform protective layer. • Atomex is the first practical gold immersion solution containing no free cyanide. It eliminates need for costly analytical controls. Write for technical data.

CHEMICAL DIVISION
113 ASTOR STREET • NEWARK, N. J.



CONTROL TEMPERATURE, CURRENT AND VOLTAGE WITH THERMOMETAL®

Leading manufacturers rely on the dependable performance of Wilco Thermometal in electrical appliances, thermal cutouts, heating controls and many other applications involving the indication and accurate control of temperatures, electrical currents, voltages, etc. Thermometal is supplied in strip form, rolled and slit to close tolerances and tempered to specification. Thermometal elements and sub-assemblies are also supplied to specifications, with or without contacts attached. Send for literature.

H. A. WILSON DIVISION
U.S. HIGHWAY 22 • UNION, N. J.

FOR RTD CIRCLE 45 ON READER-SERVICE CARD
FOR THERMOMETAL CIRCLE 46 ON READER-SERVICE CARD

ENGELHARD
INDUSTRIES, INC.
EXECUTIVE OFFICES:
113 ASTOR STREET • NEWARK 2 NEW JERSEY

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Please send literature as indicated below, addressed to my attention:

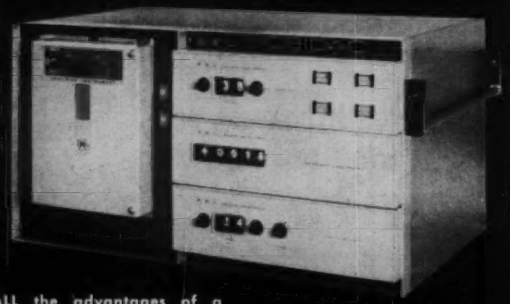
☐ Econotape ☐ Rhodium Plating
☐ Fine Wire ☐ SilvaBrite Silver Plating
☐ Platinum Spirals ☐ Atomex
☐ Thermometal

NAME .....
TITLE .....
FIRM .....
STREET .....
CITY ..... ZONE ..... STATE .....

FOR GOLD IMMERSION CIRCLE 47 ON READER-SERVICE CARD

NOW PORTABILITY plus ACCURACY and up to

50% SAVINGS IN COST!



All the advantages of a conventional multi-rack data system in one PORTABLE package!

MOBIDAC

MOBILE DATA ACQUISITION SYSTEM

A Reliable and Economical Way to Record

√ STRAINS
√ PRESSURES
√ TEMPERATURES
√ POSITION INFORMATION

- CONNECT YOUR TRANSDUCERS DIRECTLY to MOBIDAC. No external d-c channel amplifiers required.
- GUARANTEED DIRECT COMPATIBILITY with all major computers. No tape translation required.

CONDENSED SPECIFICATIONS

Data Channels 48
Input Levels ± 4 millivolts to ± 4 volts
Accuracy (full scale) 0.1%
Sampling Programs Selectable by front panel switch
Sampling Rate Up to 3000 sps
Display Decimal display for individual channel data
Output Format Gapped or gapless for all major computers
Test Identification Run number is inserted on tape at beginning of test for identification
Size.....36" x 20" x 24"
Weight .....175 pounds
Supply Voltage.....115 a-c volts

90 DAY DELIVERY

OPTIONS: Increased channel capacity . . . 100 or more, Higher Sampling Speeds, Quick-Look Display, Punched Tape and Card Outputs.

For Detailed Specifications and Prices, write Dept. IC

SEL

SYSTEMS ENGINEERING LABORATORIES, INCORPORATED

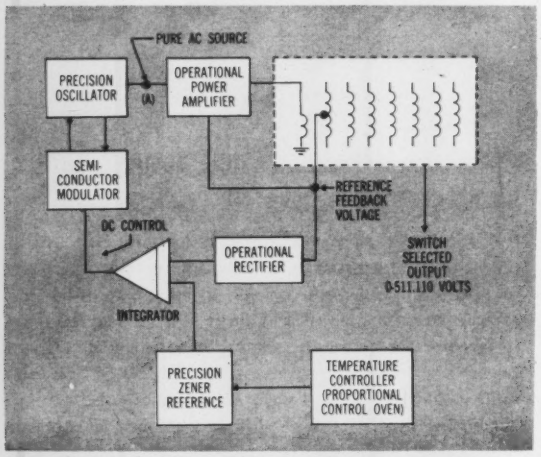
LOgan 4-7616 • P. O. Box 9148

4066 Northeast Fifth Avenue • Fort Lauderdale, Florida

CIRCLE 48 ON READER-SERVICE CARD

AC Absolute Voltage Standard

The basic AC source of the Model 146A Absolute Voltage Standard is a precision oscillator, whose output amplitude is controlled via a simple semiconductor modulator, with set point defined by an externally-introduced, loop-controlled dc feedback signal. Oscillator output (A) is supplied to the Operational Power Amplifier, with one



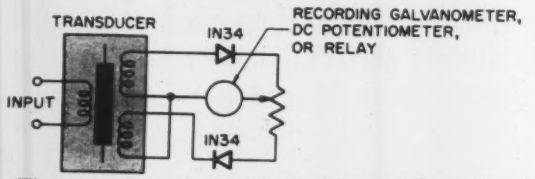
megacycle bandwidth and ten volt-ampere output capability. The power Amplifier in turn drives a precise ratio transformer, whose secondaries are arrayed in six-digit decimal form for switch-selected outputs between 0 and 0-511.110 volts in one-millivolt steps.

A Reference Feedback voltage is derived from one of the ratio transformer secondaries, for Power Amplifier feedback. The same Reference Feedback voltage is also full-wave rectified in the Operational Rectifier, and compared against the temperature-controlled stable zener reference by means of an integrator. Integrator output is fed to the DC Control input in the Oscillator, closing the system feedback loop . . . (*From Bulletins 146A and 101, Rotek Instrument Corp., 733 Concord Ave., Cambridge 38, Mass.*)

CIRCLE 251 ON READER-SERVICE CARD

Linear Displacement Transmitter

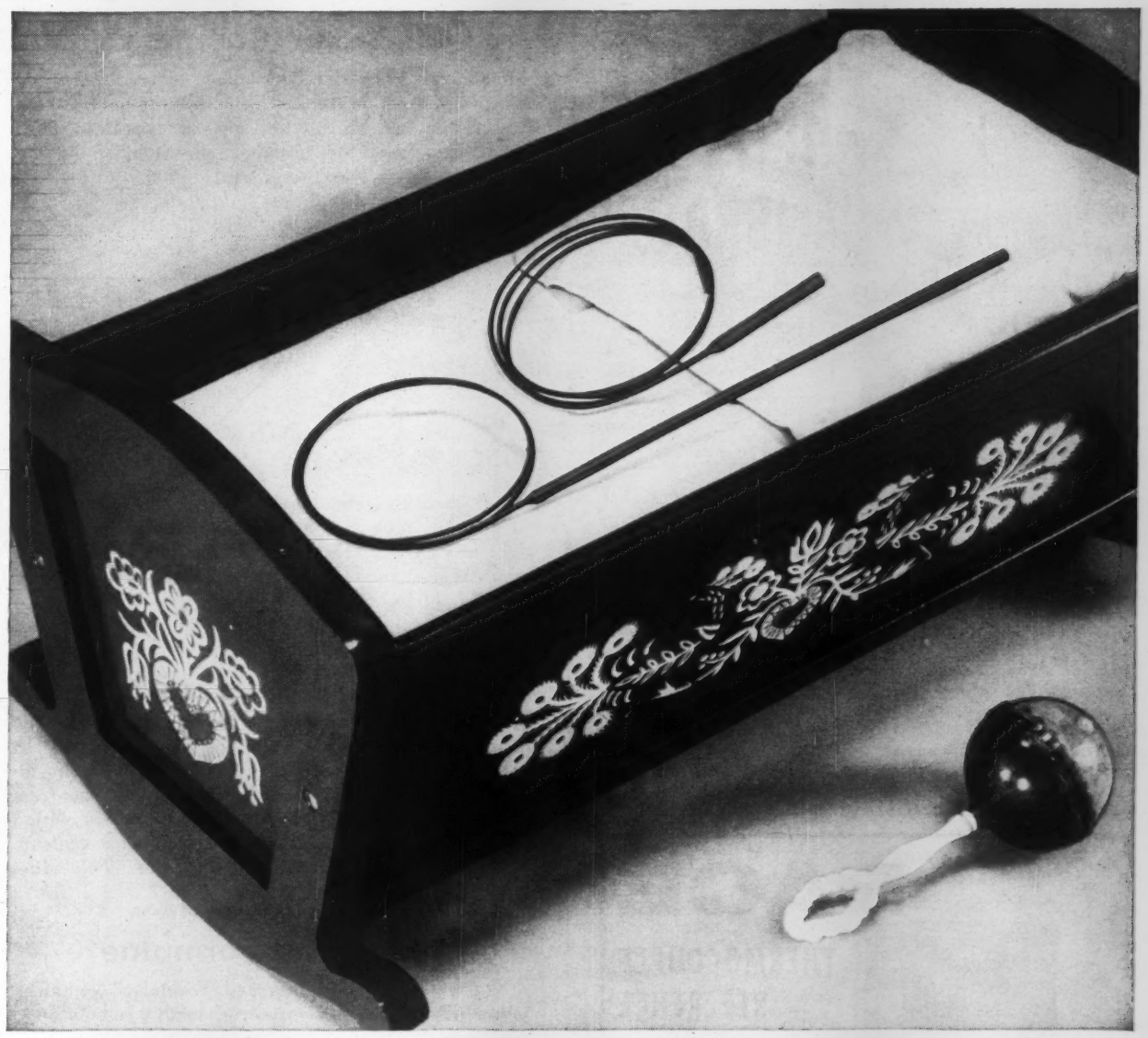
The Linear Displacement Transmitter is an exceptionally high output transducer . . . The electrical sensing element is a specially designed differential transformer



. . . The transmitter is energized with an AC carrier signal (at 60 to 6,000 cps). The output is an AC voltage directly proportional to the linear displacement of the spring-loaded plunger. The output voltage reaches null at a central position and shifts 180° in phase as it passes through the null position . . . (*From new 2-page bulletin Dynamic Measurements Co., Terwood Rd., Willow Grove, Pa.*)

CIRCLE 252 ON READER-SERVICE CARD

Continued on page 2021



New from Kensico: one-piece capillary tube and bulb assembly, in sizes for all types of instrumentation work. This new one-piece assembly for thermosensing elements is painstakingly produced by Kensico technicians using the utmost care to insure customer's exact specifications. Range offered includes bulb sizes up to ⅜″ OD maximum, by any desired length, with capillary tubing down to a minimum of 0.010″ ID.

NEWBORN!

Single-piece design eliminates a joining operation in the assembly of instrumentation systems and gives the added efficiency of joint-free flow. Kensico normally ships these units in straight lengths although they are shown above coiled to indicate design. Call Kensico today. Discover how well deserved is our reputation as a Small Tube Specialist. Write KT-61, Kensico Tube, Mount Kisco, N.Y. for free copy of Air Flow Engineering Charts.

Kensico Tube
COMPANY DIVISION
Robinson Technical Products, Inc. • MOUNT KISCO, NEW YORK

Kensico Products are also available through Warehouse Distributors and Sales Representatives in Cambridge, Mass.; Middlebury, Conn.; Buffalo, N. Y.; Lindenhurst, N. Y.; Goshen, N. Y.; Roselle, N. J.; Philadelphia, Pa.; Flourtown, Pa.; Pittsburgh, Pa.; Cleveland, Ohio; Chicago, Ill.; St. Louis, Mo.; Milwaukee, Wisc.; Durham, N. C.; Dallas, Texas.

CIRCLE 49 ON READER-SERVICE CARD

PORTABLE PRESSURE CALIBRATOR

Quick, on-the-spot calibration of pressure gauges, transducers and their systems with a compact unit.

- Laboratory accuracy under field conditions.
- Ultimate in high precison pressure measurements.
- Compact and portable for field use.
- Guaranteed accuracy ±.15%, including factors of temperature, hysteresis and calibration.
- Uses safe dry nitrogen.
- Compact carrying cases contain instrument and gauges.
- Choice of gauges from 60 PSI to 6,000 PSI.
- Easy to operate.

Write for Technical Brochure T511

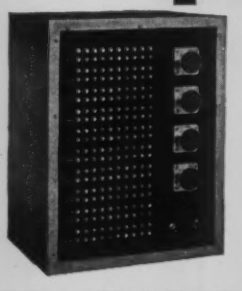
MARTIN DECKER

Precision Pressure Instruments Testing—Weighing—Load and Force Measurement

MARTIN-DECKER CORPORATION *3431 Cherry Ave., Long Beach 7, Calif.*
BRANCH OFFICES: Cleveland 14, Ohio, 1787 East 24th St. - Philadelphia 7, Pennsylvania, 324-26 No. 9th St.

CIRCLE 50 ON READER-SERVICE CARD

PACE



THERMOCOUPLE REFERENCE JUNCTION

PACE BRJ SERIES UTILIZES MAGNETIC AMPLIFIER CONTROL FOR EXTREME PRECISION —

1/5°F STABILITY

- **REFERENCE TEMPERATURES** from 25° F above ambient to 250° F — *special models for reference temperatures below ambient.*
- **CHANNEL CAPACITY** 6 to 100 channels in standard 110 volt rack or cabinet models.
- **MULTI-WIRE** junctions for thermocouple choice in each channel.
- **THERMOCOUPLE TABLES** for 150° F reference available. Write for your copy.

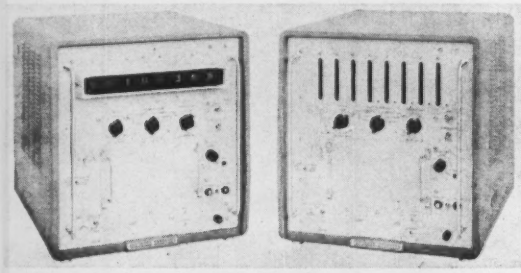
PACE *engineering company*
13035 Saticoy St., North Hollywood, California · Phone POplar 5-0453

CIRCLE 51 ON READER-SERVICE CARD

Electronic Counters

Model 524C and 524D Electronic Counters provide for frequency and period measurements from 0 cps to 10 mc automatically and directly in one self-contained unit, without calculation or interpolation. Stability of the crystal oscillator has been increased over that of the well known 524B to 3 parts in 10^8 short term.

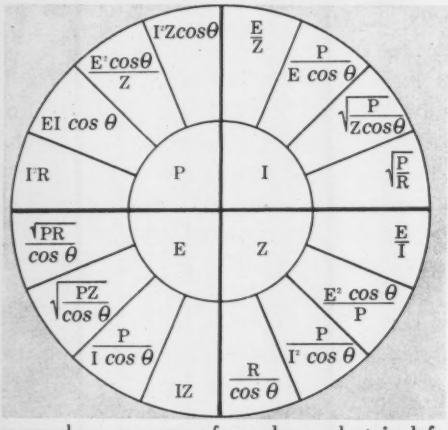
The Model 524C presents data directly in an improved single line display. Reading errors are reduced and operator fatigue is lessened since the numerals are bright and easy to read under all ambient lighting conditions. A polarized light filter stops the reflection of external light from the number elements . . . Inexpensive plug-in units allow the frequency measurement range to be extended upward to 510 mc in decade steps, allow period measurements over 10,000 periods, and also provide increased sensitivity for measurements of weak signals. The 540B Transfer Oscillator and Model P932A Harmonic Mixer further extend the range of the counters to 18 gc. In addition, the 526B plug-in unit provides the input circuits required for time-interval measurements from 1 microsecond to 100 days, with a maximum resolution of 0.1 microsecond . . . (*From new 4-page bulletin, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.*)



CIRCLE 253 ON READER-SERVICE CARD

Tables and Formulae

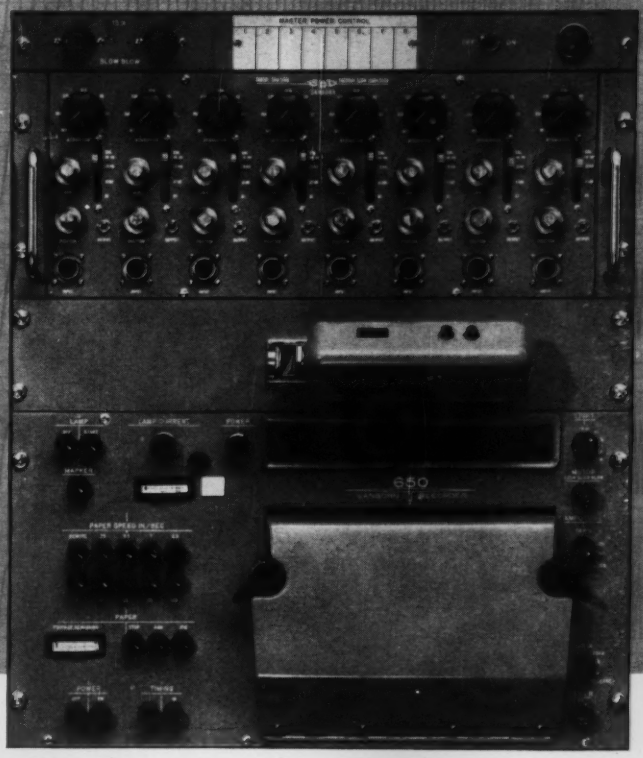
32-page booklet, "Tables and Formulae" contains tables of weights and measures, math symbols and constants, the Greek alphabet, temperature conversions,



binary numbers, powers of numbers, electrical formulae, the fundamentals of Boolean algebra, Ohm's Law for alternating current, etc.—*Write Director, Control Equipment Sales, Industrial Products Div., Automatic Electric Sales, Northlake, Ill.*

CIRCLE 254 ON READER-SERVICE CARD

DC to 5000 cycles over an amplitude of 4" peak to peak



NEW SANBORN "650" SYSTEM OFFERS DIRECT READOUT, 8 TO 24 CHANNELS, ALL SOLID STATE CIRCUITS, FOR RACK MOUNTING OR INDIVIDUAL CASES.

Here's the *one* system that lets you record inputs from DC to 5 KC within 3 db at 4" peak-to-peak amplitudes, without changing galvanometers. The "650" system consists of an 8-channel medium gain, general purpose amplifier unit driving a high speed, high resolution optical oscillographic recorder. It can be easily built into your system, packaged in a mobile cabinet or housed in individual cases. The single-chassis, 7" high amplifier module has 8 separate channels, *complete from floating and guarded inputs to galvanometer outputs;* each channel comprises a front end modulator and input transformer, carrier amplifier, demodulator, filter and driver amplifier. Power Supply and Master Oscillator Power Amplifier are built-in. All amplifier elements are plug-in transistorized units for easy servicing.

Immediately readable recordings are made on 8" wide daylight-loading ultra-violet-sensitive charts which require no chemical development. Features of the 12¼" high recorder unit include 9 electrically controlled chart speeds from ¼" to 100"/sec; calibrated monitoring screen; automatic trace identification and timing lines at 0.01 or 0.1 sec. intervals; amplitude lines spaced 0.1" apart which can be blanked from ¼, ½, ¾ or all of chart. Recorder is available with an 8-, 16- or 24-channel galvanometer block which is then equipped with the number of galvanometer elements desired by the customer. Either the Recorder or Amplifier are also available as individual units for use with other equipment.

SENSITIVITY 20 mv input gives 8" deflection; 12 attenuator steps to X5000, smooth gain control.

INPUT RESISTANCE 100,000 ohms all ranges, floating and guarded; DC source resistance must be kept below 1000 ohms on mv ranges only.

COMMON MODE PERFORMANCE Rejection at least 140 db at DC, tolerance to ±500 volts, max.

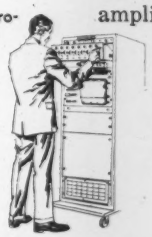
GAIN STABILITY Better than 1% to 50° C. and for line voltage variation from 103 to 127 volts.

LINEARITY 1½% of full scale (8 in.)

NOISE 0.02" peak-to-peak, max.

MONITOR OUTPUT On front panel; provides ±1v full scale across 100,000 ohm load

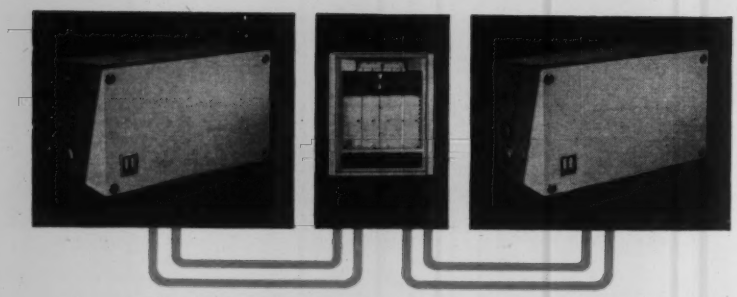
POWER REQUIREMENTS 103-127 volts, 60 cycle AC, 625 watts



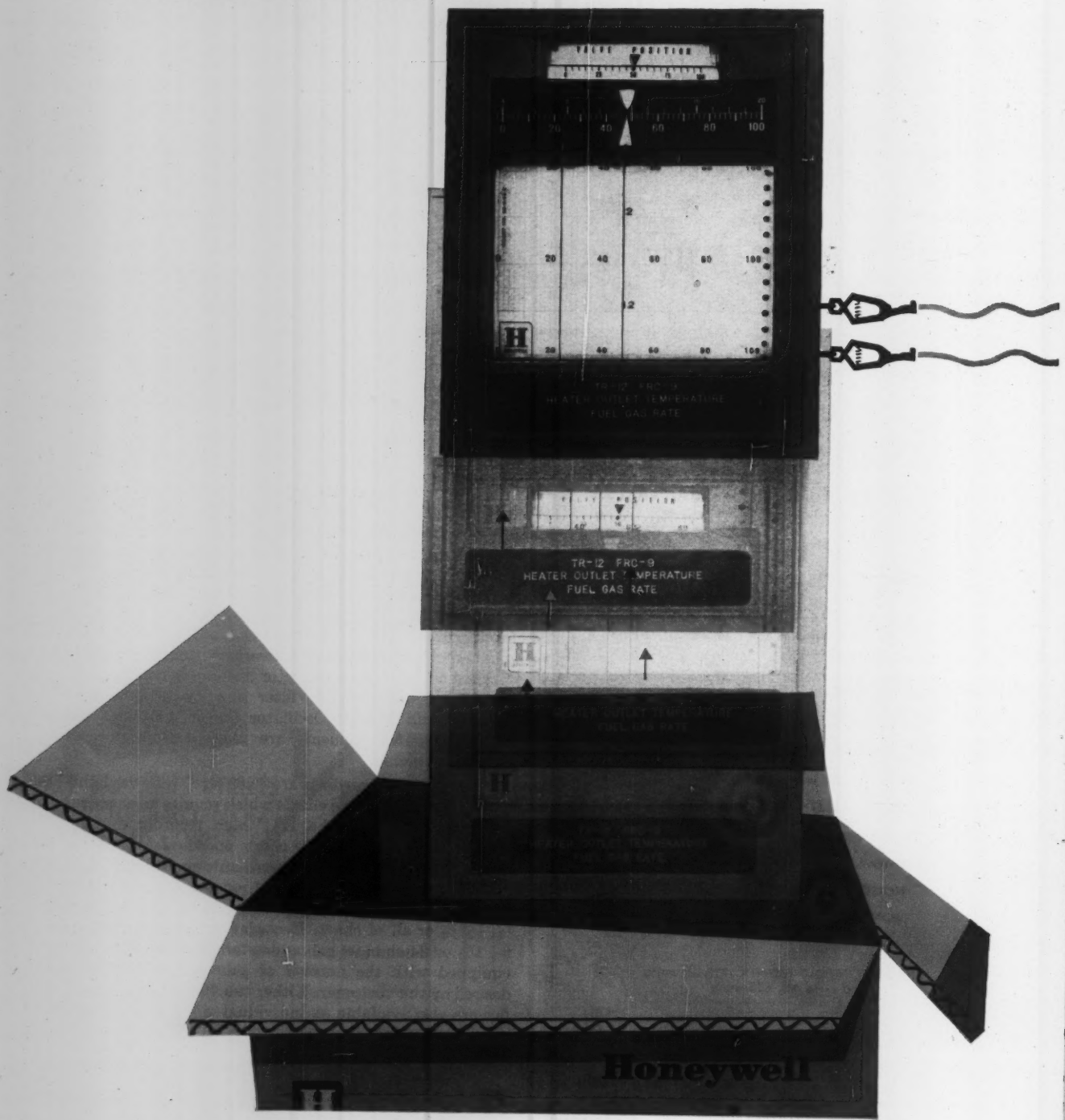
Contact your Sanborn Sales-Engineering Representative for complete specifications and applications engineering assistance. Offices throughout the U. S., Canada and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman St., Waltham 54, Massachusetts

CIRCLE 52 ON READER-SERVICE CARD



***ElectriK Tel-O-Set*—the true 2-wire system**



This "Loop Snooper" adds to the extraordinary ease of installation and maintenance you'll find in the *ElectriK Tel-O-Set* System. It's a portable test instrument that can accurately check . . . from the control panel . . . any *Tel-O-Set* unit in the field, to make sure signals are being received and sent exactly as they should be. Or it can operate and check a recorder chassis, indicator chassis or controller on the bench, with local power. The "Loop Snooper" removes trial and error from installation and maintenance.

SIMPLEST TO INSTALL, ADJUST AND MAINTAIN

The *ElectriK Tel-O-Set* System has many features that save time in getting on stream, and keep maintenance to a minimum. For example, all process connections are isolated from the inside of *Tel-O-Set* transmitter and transducer cases, so that you can mount, pipe and wire the instruments without removing their covers. Instrument chassis can be removed for servicing without breaking any external process or electrical connections. Standardized parts and extensive use of quick-connect and plug-in design cut downtime and spare parts requirements.

No external power is required at any field-mounted *Tel-O-Set* instrument; line power is connected only at the receiver. Two-wire d-c transmission eliminates shielding and further reduces installation costs. The 4-20 milliamp signal range gives a *live* zero through the use of readily available reliable transistors.

Your nearby Honeywell field engineer can tell you how *ElectriK Tel-O-Set* advantages relate to your particular control requirements. Call him today . . . he's as near as your phone. Or write to MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Massachusetts.

Honeywell

First in Control

SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

CIRCLE 53 ON READER-SERVICE CARD

NEW

...through research by Barber-Colman

Model 30D Automatic Dewpoint Controller

INDICATES, RECORDS and CONTROLS

moisture content of protective gas atmospheres

VERSATILE OPERATION

Specially designed for metalworking and packaging processes, Model 30D controls degree of oxidation-reduction and/or carburizing-decarburizing of atmosphere for generators and furnaces.

WIDE DEW POINT RANGE

Model 30D detects and controls dew point in the range of −50°F to +110°F with any select span of 50° F. Assures high control accuracy within ±.5° F.

EASY MAINTENANCE

Vapor state sensor does not condense out moisture sample. This eliminates troublesome refrigeration and reduces contamination. Model 30D requires minimum filter changes . . . inexpensive filter changed in 30 seconds. System incorporates readily accessible, time-proven components.

ULTRA-FAST RESPONSE

A unique sensor design — moisture is not condensed during the continuous detection process. This makes possible a 5-second response speed per 10 ft. of sample line.

LOWER OPERATING COSTS

Low gas flow — 15 cu. ft. per hour sample gas for low waste and fast response. Low power consumption. Model 30D sensor reduces operating costs by eliminating the replenishing of salt procedure.

SIMPLE MODULAR DESIGN

Model 30D features minimum moving parts and maximum design simplicity. Indicating and control section can be remote from sensing unit for centralized control.

Contact Barber-Colman today.

BARBER COLMAN

BARBER-COLMAN COMPANY

Industrial Instruments Division

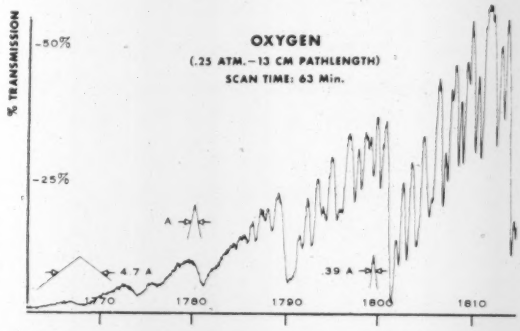
Dept. W, 1515 Rock Street, Rockford, Illinois, U.S.A.

BARBER-COLMAN of CANADA, Ltd., Dept. W, Toronto & Montreal • Export Agent: Ad. Auriema, Inc., NY

CIRCLE 54 ON READER-SERVICE CARD

Recording Spectrophotometer

The Cary® Model 15 Spectrophotometer is designed and manufactured especially for the rapid recording of spectra with a high degree of accuracy, flexibility and reliability . . . Exceptional care has been given to the

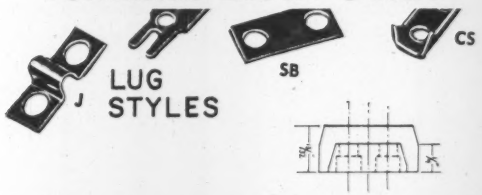


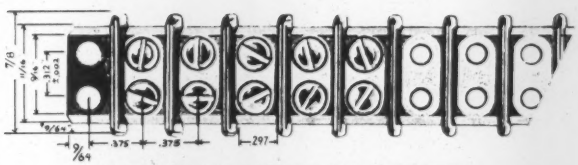
design of systems, and components provide superior resolution, high photometric and wavelength accuracy, high light purity, with versatility and convenience for a wide variety of problems . . .

The Model 15 monochromator is a double mirror-collimated Littrow type with two 30° fused silica prisms selected for high ultraviolet transmission . . . The wavelength scale is continuous form 1600 A to 8000 A, direct reading from panel indicator . . . The oxygen spectrum showing the Schumann-Runge bands illustrates the high resolution achieved in the 1750 to 1865 Angstrom region (light path purged with nitrogen). Spectral slit widths shown are corrected for slit curvature and aberrations . . . (*From new 8-page Bulletin 115A, Applied Physics Corp., 2724 South Peck Rd., Monrovia, Calif.*)

FOR THIS LITERATURE CIRCLE 255 ON READER-SERVICE CARD

Terminal Block Guide





AUXILIARY HARDWARE CODES

L—Solder terminal, feed-thru type
U—Solder terminal, one sided
UU—Solder terminal, two sided
J—Jumpers
SB—Shorting bar
CS—Connector Strip terminal
T—Taper Pin Terminal
I—Sem screw with internal tooth phosphor-bronze lockwasher
E—Sem screw w/external tooth p-b l.w.
M—Sem screw w/monel split l.w.
W—Plain flat standard size washer
S—Sem screw w/ stainless steel l.w.

(*From 6-page Catalog XLX-7A, Excellex Electronics, Inc., 88-06 Van Wyck Blvd., Jamaica 18, N. Y.*)

FOR THIS LITERATURE CIRCLE 256 ON READER-SERVICE CARD

Continued on page 2024

GUBELMAN
CHARTS
PAPERS·INKS
for Recording Instruments
We offer to the instrument maker
CHARTS
for all methods of recording, including Pen, Ball Point, Electrical, Thermal and Pressure, in roll or flat form.
INKS
for Diazo and general use.
PAPERS
Heat, pressure and electrical sensitive papers of all types. Sole suppliers of Nashua's Heatrace*, Prestrace*, Electrace* Charts.
*TRADEMARK
GUBELMAN CHARTS
DIV. OF NASHUA CORPORATION
100-6 E. KINNEY ST., NEWARK 5, N. J.

BINARY OPERATED READOUT

New!

Operates Direct — No Buffers or Translators Required

ALL DIGITS CAN BE READ FROM ANY ANGLE

Self-Decoding Alpha-Numeric Readout

BINA-VIEW

Price Complete from $50.00

Applications . . . May be connected directly into computers, teletype, other electronic equipment.

Features . . . . . Electro-magnetic operation, low power (10 milliwatts), accepts BCD code to 6 bits, does own translating and displays proper character.

Specifications . Speed: 20 characters per sec. Character Size: 1⅜" high. Dimensions: 1¾" x 3¼" x 6¾".

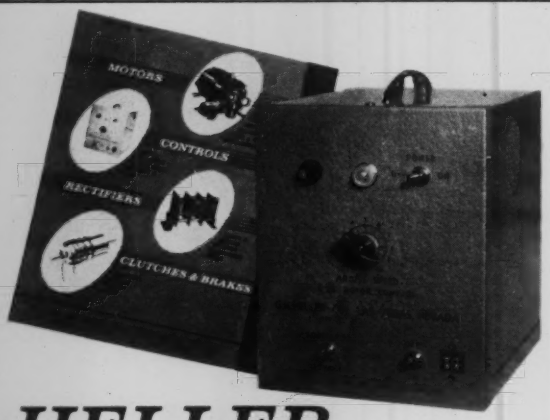
WRITE TODAY FOR COMPLETE DETAILED INFORMATION.

Representatives in principal cities.

INDUSTRIAL ELECTRONIC ENGINEERS, Inc.

5528 Vineland Avenue, North Hollywood, California

CIRCLE 55 ON READER-SERVICE CARD



HELLER THYRATON & SOLID STATE CONTROLLERS

Call us for off-the-shelf delivery — Geared & Non-Geared Electric Motors — Heller Solid State & Thyraton Controllers — Selenium & Silicon Rectifiers — Simplatrol Electric Brakes & Clutches. Send us your specifc inquiries — write for our latest catalog. **B & B MOTOR & CONTROL CORP., 206 Lafayette Street, New York 12, N. Y. WOrth 6-5777**

CIRCLE 579 ON READER-SERVICE CARD

Want More Information?

- **PRODUCTS ADVERTISED**
- **NEW INSTRUMENTS ANNOUNCED**
- **NEW LITERATURE REVIEWED**

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USE THE POSTAGE FREE INQUIRY CARD BOUND IN EACH ISSUE OF . . . . .

I & CS

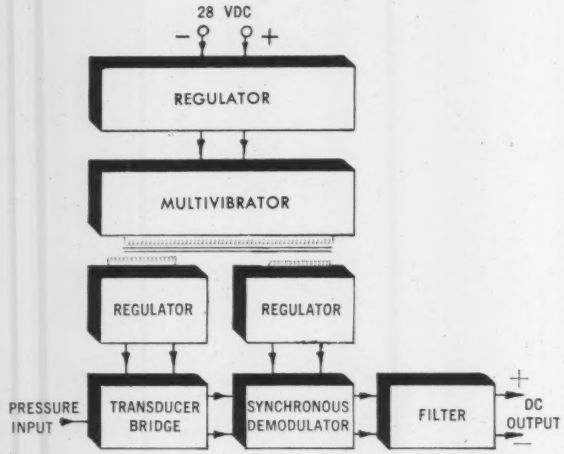
it's a time Saver!

COMPLETE THE CARD AND MAIL

It's fast and Easy

Pressure-To-D-C Transducer

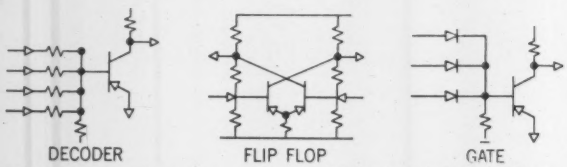
Model DC-2000 Deeceeducer combines a variable-reluctance diaphragm-type pressure transducer with an all-silicon solid-state synchronous modulator-demodulator circuit to provide a complete in-line instrumentation module for the linear conversion of pressure to a proportional d-c voltage. The DEECEEDUCER is excited from an unregulated 28-volt d-c supply. A regulated transistorized multivibrator generates a square-wave drive to a variable reluctance bridge and a synchronous transistor demodulator. The bridge output is proportional to the pressure input and is demodulated and filtered to provide a highly linear zero-to-5 volt d-c output proportional to the full-scale pressure rating of the transducer. Pressure ranges extend from 5 to 5000 psi in gage, absolute and differential pressure types . . . (*From new 2-page bulletin, Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif.*)



CIRCLE 580 ON READER-SERVICE CARD

AC/DC Digital Measurements

The EItronic series includes all-electronic 4 and 5 digit AC and DC voltmeters and ratiometers, and 4 digit all-electronic ohmmeters. 6 models in all . . . 5-digit 880 DC digital voltmeter-ratiometer, . . . 4-digit 8409 DC digital voltmeter, . . . 5-digit 882 AC/DC digital voltmeter-ratiometer, . . . 4-digit 850 AC/DC digital voltmeter-ratiometer, . . . 4-digit 848 DC Digital voltmeter-ratiometer, . . . (and) 4-digit 851 AC/DC digital voltmeter-ratiometer and ohmeter . . .



Switching is accomplished by movement of electrons and "holes" in a crystal lattice. The logic has no moving arms, no metal fatigue, no wear on contacts . . . (*From new 8-page Bulletin D516, Electro Instruments, Inc., 8611 Balboa Ave., San Diego 11, Calif.*)

CIRCLE 581 ON READER-SERVICE CARD

AE

TO THE ENGINEER

who needs the magic of mercury

If you're stymied by switching problems in data processing, automatic control or high-speed keying, then consider the unusual attributes of AE's Series V51 mercury-wetted contact relay.

This fleet switcher can be driven at speeds up to 100 operations per second, completely free from contact bounce. It requires no maintenance within its life of over a billion transfers. The contacts can switch dry circuits or handle loads up to 250 volt-amperes. Operate and release time is approximately 3 milliseconds.

Contact and armature assemblies of the V51 are hermetically sealed in a glass capsule with a high-pressure hydrogen atmosphere. Mercury wetting continuously renews the contacts, eliminates wear, erosion, welding and sticking. Operating sensitivity is 250 milliwatts, minimum.

AE engineers will be glad to aid in applying the V51 to your designs. Ask for Circular 1988 covering full specs on the V51. Write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

AE CAN DO

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

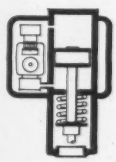
CIRCLE 56 ON READER-SERVICE CARD

Now get greater flow capacity Hammel-Dahl split-body

CHOOSE FROM THIS COMPLETE LINE OF INTERCHANGEABLE ACTUATORS

POSITIONING PISTON ACTUATOR
(Direct or Reverse)

ON-OFF PISTON ACTUATOR
(Reverse; Direct Available)



HYDRAMOTOR ACTUATOR
(Electro-Hydraulic)

See how much more flow capacity you get with Hammel-Dahl Division split-body control valves. Compare these Cv ratings with other valves now available. Prove for yourself: Hammel-Dahl "S" Style bodies have higher capacities than any conventional split-body design; Hammel-Dahl "Y" Style bodies set new standards for Cv per nominal pipe size.

This can mean substantial savings for you. You get more flow for your valve dollar . . . and more valve with Hammel-Dahl quality design!

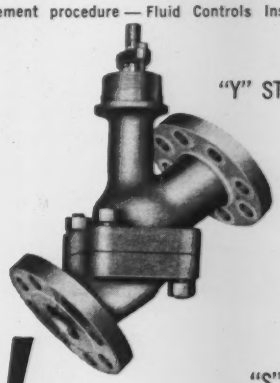
Remember, too, variety in split-body styles typifies the choice you get from Hammel-Dahl for all your valve requirements: Globe, Angle, Three-Way, Microflo, Saunders Patent, Butterfly, or Special designs.

Look at these Flow Coefficients (Cv)*
Integral flanges choice of: face-to-face dimensions and actuator types.

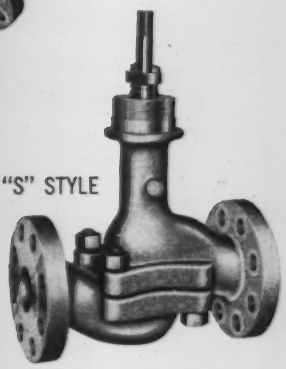
Size	1"	1½"	2"	3"	4"
On-Off	20	60	105	244	400
Throttle	18	50	100	225	380

*Flow capacity measurement procedure — Fluid Controls Institute Recommended Standard 58-2.

with NEW control valves!



"Y" STYLE

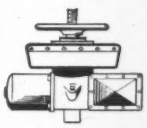


"S" STYLE

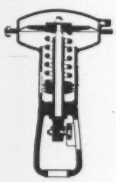
Look at these Flow Coefficients (Cv)*
Choice of: separable or integral flanges, actuator types, face-to-face dimensions. Also available: "SL" 90° angle flow pattern.

Size	½"	¾"	1"	1½"	2"	3"	4"
On-Off	4	6.3	13	33	50	135	240
Throttle	4	6.3	13	33	50	135	240

*Flow capacity measurement procedure — Fluid Controls Institute Recommended Standard 58-2.



TORK-MASTER ACTUATOR (Electric, Gear-Driven)



DIAPHRAGM ACTUATOR (9 Types Available)

MANUAL ACTUATOR

Check the yellow pages for your nearest Hammel-Dahl field representative, or write for Bulletin S-B.

Manufacturers of Control Valves and Allied Equipment

HAMMEL-DAHL DIVISION

GENERAL CONTROLS CO.

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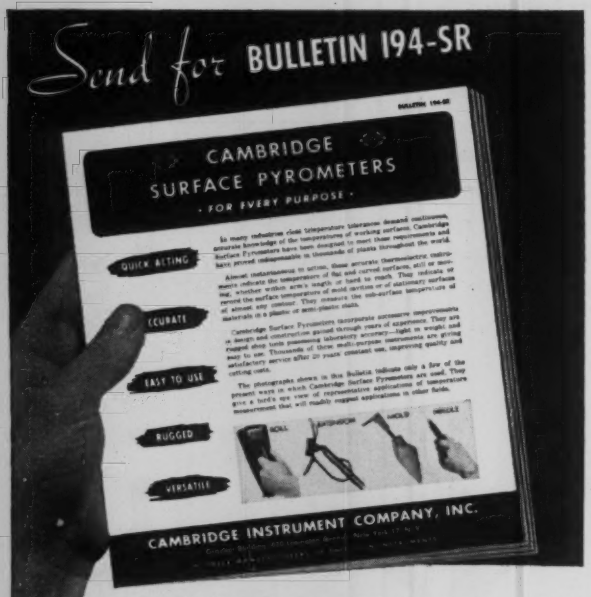
Factory Branch Offices or representatives in principal cities — United States and abroad.

CIRCLE 57 ON READER-SERVICE CARD



Cambridge Surface Pyrometers are light weight, portable instruments—accurate but rugged—for measuring temperature of mold cavities and flat surfaces drier, calender and mill rolls, and plastic batches and extrusions.

Write for Bulletin 194-SR; 33 illustrations, many plastic applications.

CAMBRIDGE INSTRUMENT CO., INC.
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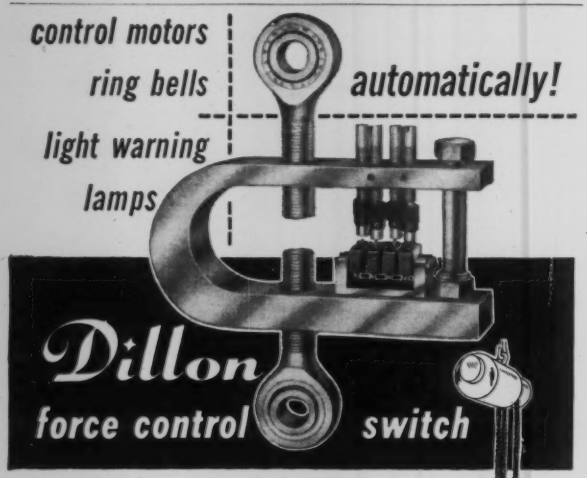
THEY HELP SAVE MONEY AND MAKE BETTER PLASTICS

CIRCLE 58 ON READER-SERVICE CARD

control motors
ring bells *automatically!*
light warning
lamps



Dillon
force control *switch*

An instrument of many uses, the Dillon Force Control Switch is triggered by mechanical forces at various load points. Available in tensile or compression. 6 ranges from 0-100 to 0-50,000 lbs. 1-4 switch models. Fully adjustable. Can be set for most critical accuracy.

STOP HOIST AND CRANE OVERLOADING

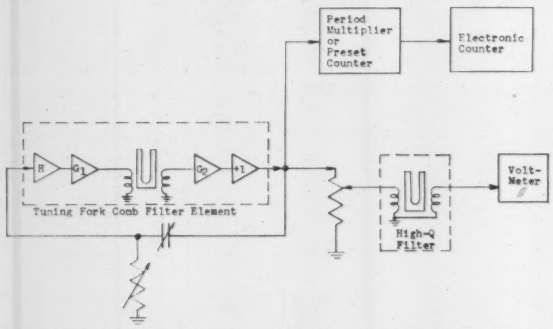
Just one example of Dillon Force Control Switch use. If load exceeds safe limit, motor automatically cuts out. Operator must press reverse switch, returning load to floor. Surplus weight must be removed before pickup can be completed. A definite protection to personnel & equipment.

Write for prices and fully illustrated brochure.

W. C. Dillon & COMPANY, INC.
Dept. 113, 14584-6 Keswick Street, Van Nuys 81, California
Representatives in All Principal Cities
CIRCLE 59 ON READER-SERVICE CARD

The Tuning Fork

Since the tuning fork can be made with a frequency accuracy and stability of a few parts per million, the measurement of its frequency-dependent parameters should be made with at least the same order of accuracy.

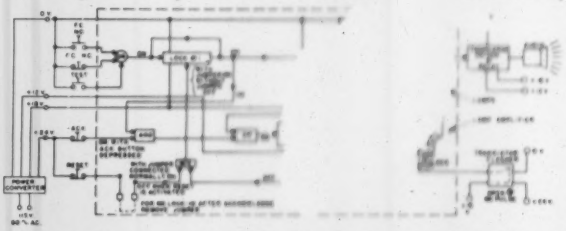


When the tuning fork is used in conjunction with an oscillator circuit in order to form a frequency standard, the problem is that of frequency measurement during alignment and environmental testing. When the tuning fork is used as a filter, an additional problem is that the signal itself must be supplied separate from the tuning fork being tested. Besides the resonant frequency of the filter, an additional measurement is the determination of Q or filter bandwidth . . . (*From* 12-*page Brochure "The Tuning Fork, A Component Rediscovered," Hathaway-Denver, Div Hathaway Instruments, Inc.*, 5800 *E. Jewell Ave., Denver* 22, *Colo.*)

FOR THIS LITERATURE CIRCLE 257 ON READER-SERVICE CARD

Solid State Annunciator Systems

In any industry where instruments are used to measure process variables, annunciators are used to call the attention of the operator to any off-normal condition occurring in the process. The annunc[illegible] continuously

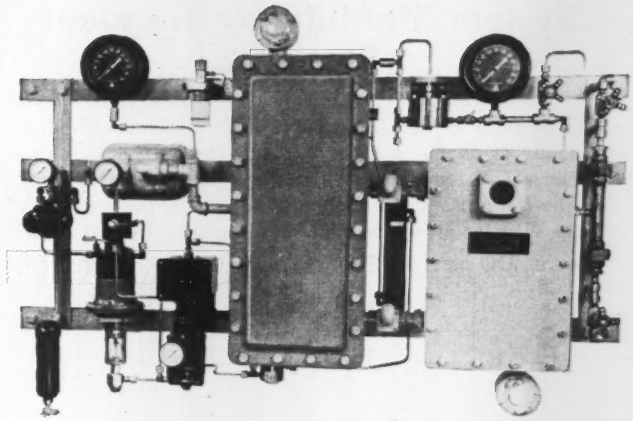


monitors all process variables by means of audible signals such as horns or bells and by means of visual signals in the form of flashing lights located behind a group of transparent nameplates . . .

Actuation of the field contacts results in the application of a signal to the module which actuates the audio control circuit and through this the audible alarm. This signal also results in the actuation of the lamp amplifier. At this stage the light output is modulated by a solid state flasher, located in the power supply unit, thus providing a flashing, visual signal. All modules operate from a common power supply will flash in unison . . . (*From new* 12-*page Publication* 3060, *Thomas A. Edison Industries, McGraw Edison Co., Instrument Div., West Orange, N. J.*)

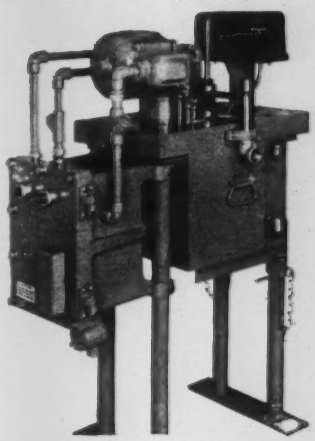
FOR THIS LITERATURE CIRCLE 258 ON READER-SERVICE CARD

Continued on page 2026



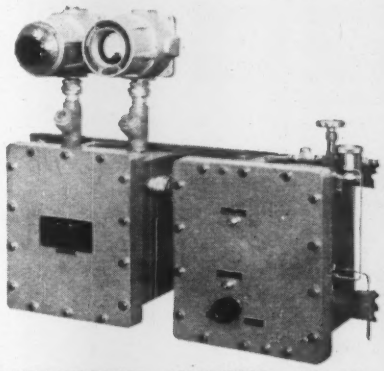
VAPOR PRESSURE ANALYZER (left), pay out: one to three months. Continuously samples and records vapor pressure of gasoline or liquefied gases in a flowing stream.

CONTINUOUS VISCOMETER (right), decreases greatly the cost of plant operation by reducing laboratory analyses of viscosity; aids operators in fast, efficient, quality control of refinery operations. Explosion-proof design. Reliable. Rapid pay out.

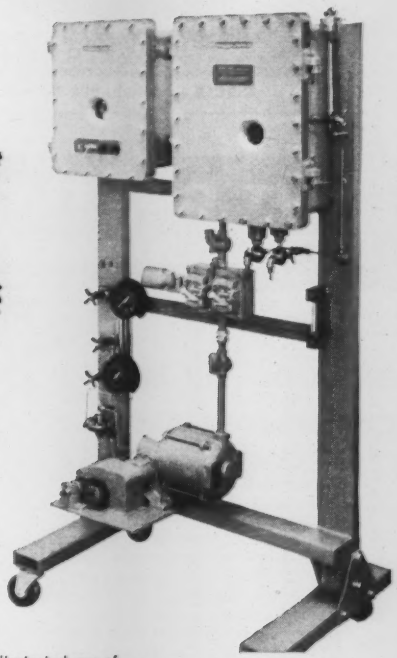


HALLIKAINEN INSTRUMENTS is headquarters for Process Stream Analyzers

Hallikainen Process Stream Analyzers help to reduce costs and improve products. Get all the facts from Hallikainen Instruments, headquarters for process stream analyzers and other precision equipment. Shown here are the latest components for automation, all of which have been proven in everyday operation.

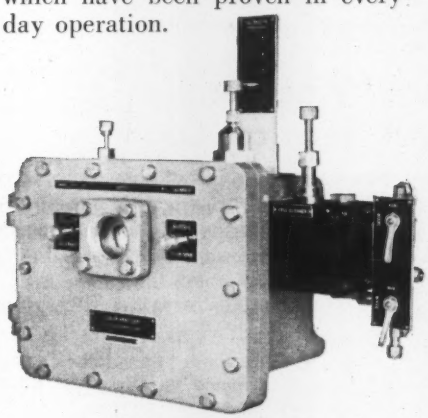


ULTRAVIOLET ANALYZER (above), instantly and continuously measures ultraviolet absorbing components in process plant streams, such as aromatics, diolefins, ketones and aldehydes. Determinations: from few parts per million to high percentages.



BOILING POINT ANALYZERS: Pictured to the right is END POINT model. Analyzers are of two types. (1) Initial and 10%, and (2) below 90% to end point. Both models are continuous; they lower costs, give better yields and uniform products because of immediate tower control. Pay out: 30 to 60 days.

(All products illustrated are of Shell Development Company design)



COLOR ANALYZER (above), gives electrical output signal to permit the recording of color of petroleum products in color range from pale yellow to deep red. Uses ASTM glass color-standards for calibration purposes.

Two of many other Hallikainen products (not shown): (1) *ALKYLATION ACID ANALYZER* for determining the strength of acid in sulfuric acid alkylation plants; (2) *MICROMALYZER*, a low cost, compact precision chromatographic laboratory instrument for detection of hydrocarbons.

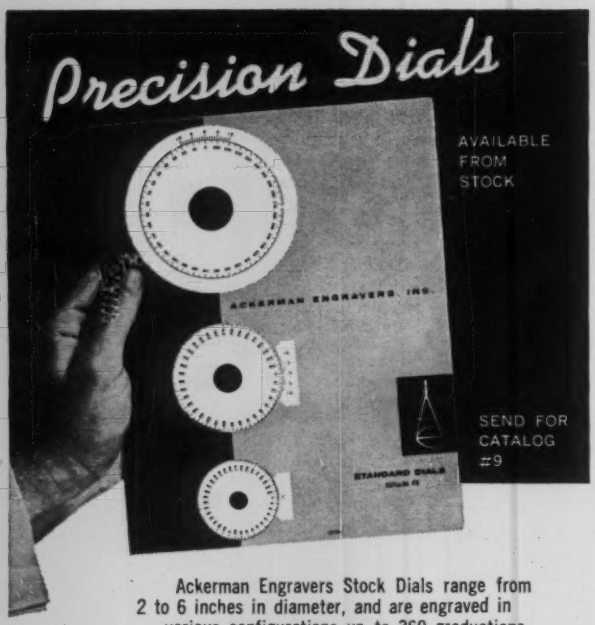
Write us today for full technical details

HALLIKAINEN *Instruments*

1341 Seventh Street **Berkeley 10, California**

Phone: LAndscape 4-1757

CIRCLE 60 ON READER-SERVICE CARD



Ackerman Engravers Stock Dials range from 2 to 6 inches in diameter, and are engraved in various configurations up to 360 graduations, clockwise and counter-clockwise. Ring dials, drum dials, verniers, knobs, and hubs are also available. A number of finishes all of which meet military specifications can be had.

Whatever your Dial specification, stock or custom consult Ackerman Engravers.

ACKERMAN ENGRAVERS, INC.
43-22 36 St., Long Island City 1, N.Y.

CIRCLE 61 ON READER-SERVICE CARD

CUT COSTLY INSTRUMENT MAINTENANCE

with

Clean Dry Oil-Free Compressed Air

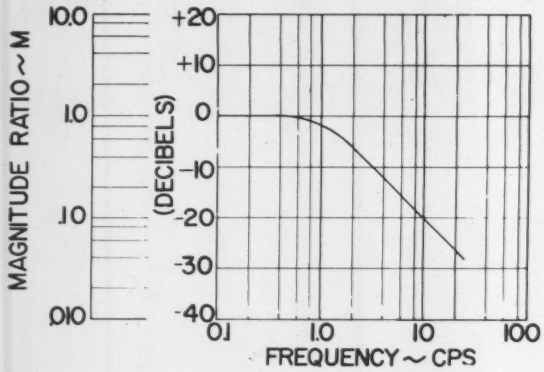
An Adams aftercooler and cyclone separator installed in your instrument air supply cools the discharge air to within 2° of cooling water temperature. Over 90% of the moisture and virtually all of the oil are condensed. The exclusive Adams cyclone separator then removes the condensed liquid oil and water and other foreign material with uniform high efficiency — over the entire operating range. This air is entirely suitable for air motor and most control applications. When bone dry air is needed, the chemical drier load is then limited only to polishing action, since the bulk of the moisture will have been removed by lower cost condensation. Why not review the cost cutting advantages of an Adams aftercooler-separator combination? Ask today for your free copy of Bulletin 715. R. P. Adams Co., Inc., 265 East Park Drive, Buffalo 17, New York.

ADAMS *QUALITY COMES THROUGH*

CIRCLE 62 ON READER-SERVICE CARD

System Stability by Frequency Response

In studying the dynamic behavior of a given control element, it is logical to supply the element with a dynamic or changing input . . . The results becomes much easier and more effective if the input is restricted to a sine-wave of appropriate amplitude and if the response of the element is observed as only the frequency is varied.



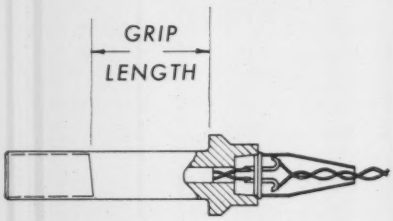
This technique is aptly called "frequency response." . . .

A very important fact concerning the stability of linear systems is now evident: stability is determined by the open-loop gain at 360° phase lag and is completely independent of load disturbances . . . Two common methods of plotting frequency response data are the Bode plot and the Nyquist diagram . . . The Bode plot is on rectangular coordinates. The phase shift and the log of the magnitude ratio are both plotted as functions of the log of the frequency. The Nyquist diagram is a polar plot. The vector of the plot has a length equal to the magnitude ratio and an angle equal to the phase shift . . . (*From* 12-*page Manual TM-8, "Generalized Control Theory," Fisher Governor Co., Marshalltown, Iowa.*)

FOR THIS LITERATURE CIRCLE 259 ON READER-SERVICE CARD

Direct Measurement of Bolt Tension Load

The Standard Strainsert Bolt installation (U.S. Pat. #2,873,341) consists of an electric strain gage bonded and sealed in a small hole along the longitudinal neutral axis of the bolt. Thus the Strainsert Bolt is capable to indicate continuously tensile stress or load induced by either tightening or otherwise loading or unloading it due to shock, vibration, wear, etc . . .



Standard Strainsert Bolt installations are available in two configurations: type C with an electrical connector, and type W with lead wires attached to a two-pin seal soldered to head of the bolt . . . (*From new* 4-*page bulletin, Strainsert Co.,* 24 *Summit Grove Ave., Bryn Mawr, Pa.*)

FOR THIS LITERATURE CIRCLE 260 ON READER-SERVICE CARD

Continued on page 2034

New
Improved
Lino-Writ 5
Use it as
a direct
writing paper
or develop it
with new
processing kit

Lino-Writ 5, proved the most dependable direct writing photo-recording paper you can use, now adds a new bonus: you can use it as a completely dry process paper, or you can process it, for permanent trace results, with Du Pont's new Direct Writing Paper Processing Chemicals Kit.

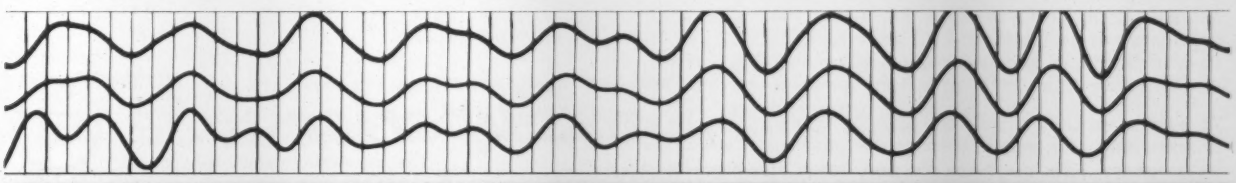
Improved Lino-Writ 5 is still outstanding for dry-processed image stability and requires no stabilizing treatment for handling under normal room light conditions. Records may now be processed for greater permanence, for making reproductions with diazo equipment or for handling for prolonged periods under intense lighting.

Improved Lino-Writ 5: up to 100,000 ips... easy-to-read traces ... and now, use it either dry or wet process.

DU PONT

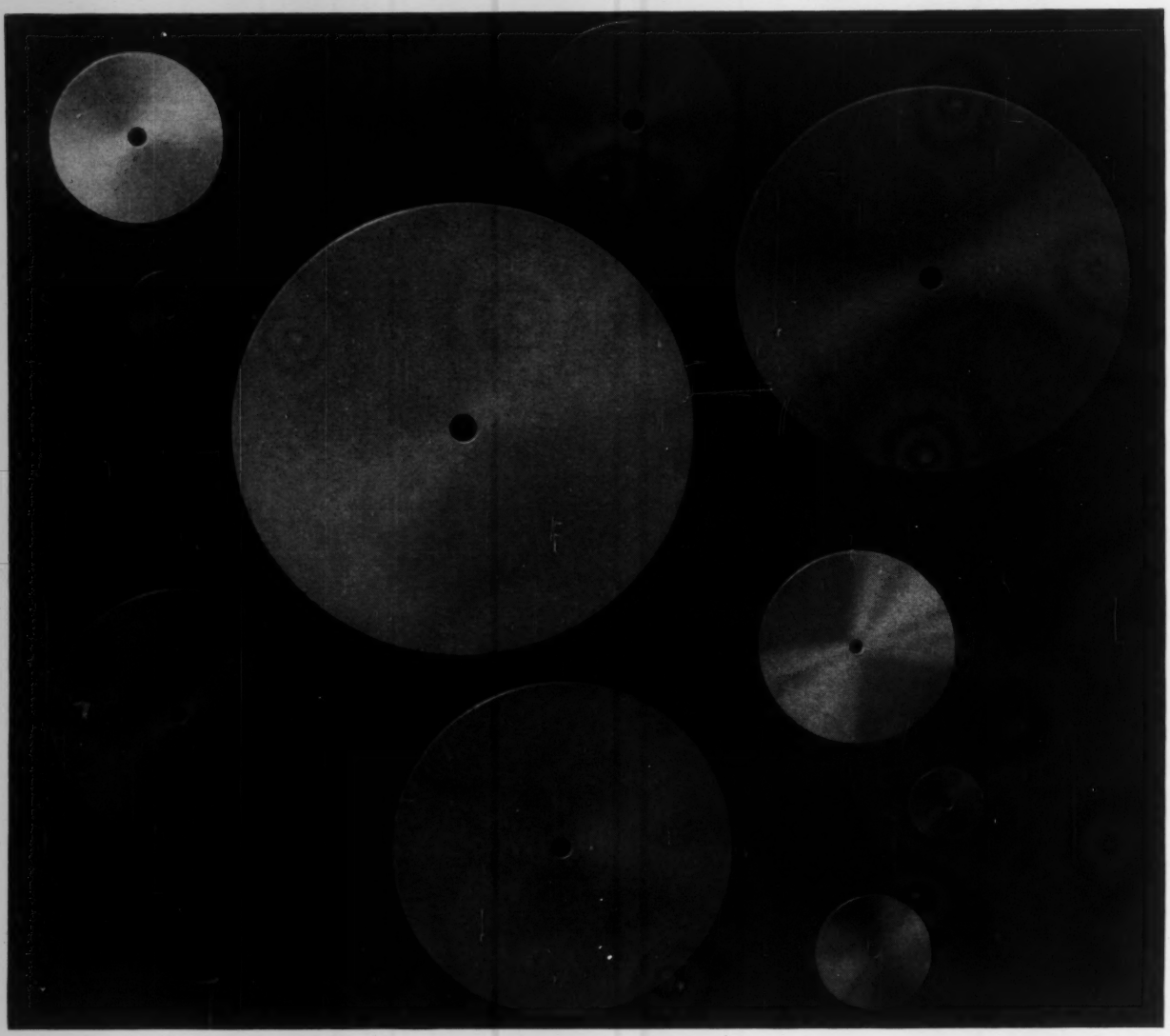
BETTER THINGS FOR BETTER LIVING... *THROUGH CHEMISTRY*

E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Del. In Canada: Du Pont of Canada Ltd., Toronto

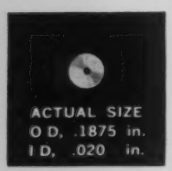


CIRCLE 63 ON READER-SERVICE CARD

Tomorrow's tubing technology—today



Magnification verifies the ID uniformity, precision and smoothness of Superior Capillary Tubing



Special manufacturing operations and quality-control procedures developed by Superior make capillary tubing a unique product. Its outstanding features include an ID that is smooth, uniform, bright and free from discoloration and held to extremely close tolerances throughout its entire length to provide effective flow characteristics. Commercial tolerances on the ID and OD are a spread of .002 in. on sizes up to .100 in. and .003 in. on sizes from .100 to .1875 in. But we can hold a .0015 or .001 in. spread when required.

To assure capillary tubing quality in volume, the ID size is checked with plug gages, then double checked in two other ways—under 100x magnification and, when specified—by a comprehensive flow inspection. These assure a uniform inner surface with free capillary action.

Superior capillary tubing is available in a size range from .030 in. to .1875 in. OD and in long lengths—up to 3000 ft.—depending on OD and wall thickness; in coils of 18, 24, 30 and 36 in.; or in random, multiple or cut lengths to specification. Analyses include Types 304, 316, 321, 347 and 446 stainless; also nickel, Monel*, Inconel*, and C 1008 carbon steel. Data Memorandum No. 11 gives complete details. Write for your copy today. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

*Reg. TM International Nickel Co.

Superior Tube ST

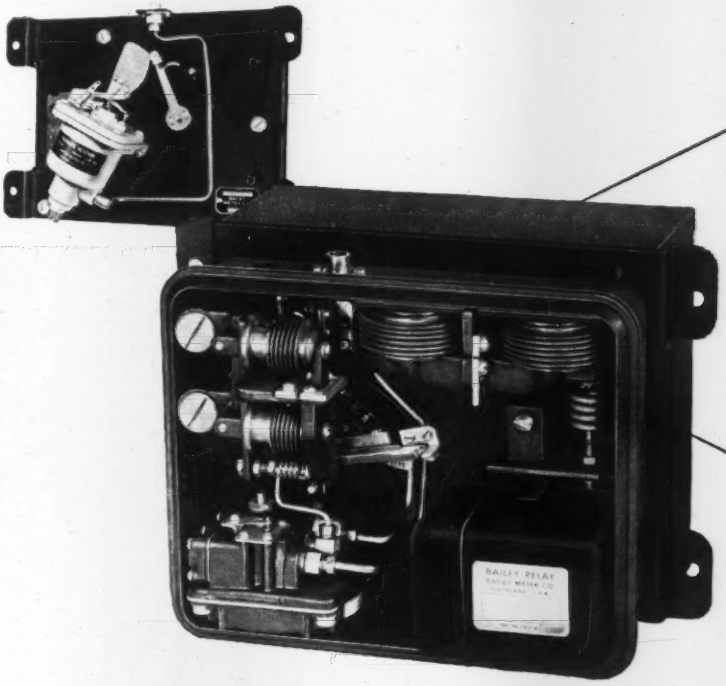
The big name in small tubing

NORRISTOWN, PA.

West Coast: Pacific Tube Company, Los Angeles, California

CIRCLE 64 ON READER-SERVICE CARD

Heart of your automatic control system...
the BAILEY COMPUTING RELAY



Performs these
COMPUTER FUNCTIONS

- MULTIPLIES • DIVIDES
- REVERSES • SUBTRACTS
- AVERAGES • TOTALIZES

pneumatic inputs

Gives these
CONTROL ACTIONS

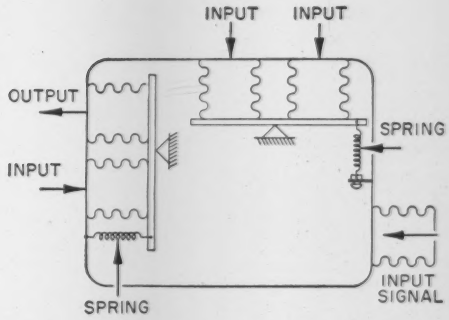
- PROPORTIONAL
- PROPORTIONAL plus RESET
- PROPORTIONAL plus RATE
- PROPORTIONAL plus RATE plus RESET
- FLOATING (reset only)

Here's quick, accurate, off-the-shelf help that can simplify automatic control-system design . . . provide almost any needed control and computing functions from multiple pneumatic input signals, flexibly and efficiently.

The Bailey Type AR80 Computing Relay is designed to receive pneumatic signals from transmitters, controllers and/or relays, and to produce an output signal which is determined by the computing and/or control functions provided in its system. It can be used singly to perform the functions indicated, or with additional units, for more complex functions.

It can also be supplied with provision for remote adjustment of proportional band. This is accomplished either with linkage drive between receiver bellows and proportional band adjustment to give linear action, or with cam drive to permit nonlinear as well as linear computations. Nozzle-vane mechanism is sensitive but sturdy—response is fast but low in air consumption. Signal ranges are standard 3-15 and 3-27 psig. Write for full specifications.

G-163-1



Multiple loading bellows gives wide flexibility By adjusting spring tensions and loading appropriate bellows, Bailey Computing Relay provides variety of functions, including: compensating flow from pressure or temperature; multiplying or dividing one signal by another; variable ratio adjustment for a different controller; adjustment of proportional band from remote manual or automatic source; introduction of nonlinear correction factor from a process stream analyzer; compensation of level measurement from specific gravity or temperature.

Instruments, controls, and systems

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

CIRCLE 65 ON READER-SERVICE CARD

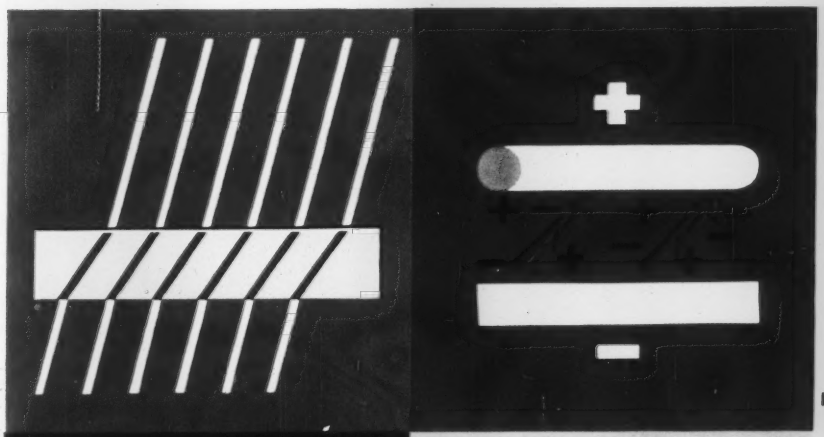
CIRCLE 66 ON READER-SERVICE CARD →

MSA Instruments apply all these principles for dependable process stream analysis

Infrared Analysis:

Now MSA delivers a modern, low-cost infrared analyzer that substantially reduces the size, complexity and high-cost of most available instruments. • The new M-S-A® LIRA® Model 300 Infrared Analyzer has the inherent reliability and accuracy of earlier MSA analyzers. But you use it in applications where extreme sensitivity isn't so essential. Lets you analyze gases, vapors and liquids fast, economically. • Weight: only 40 pounds. Size: a trim 8″ x 10¼″ x 20″. Requires only 60 watts. Available with handle for use as a portable unit. • You can use the Model 300 LIRA for handling chemical and petro-chemical process streams; for furnace atmosphere control; for humidity measurement and control; combustion control; toxic and combustible gases; for logging of oil or gas wells. Other models of M-S-A LIRA are also available for your more complex problems. • Our techniques and principles involve a number of interesting instrument concepts. They're reflected in the symbols on the opposite page. Please write for new M-S-A LIRA 300 bulletin. Or for any of our other process stream analyzer literature.

Mine Safety Appliances Company, Pittsburgh 8, Pennsylvania



Refraction

Ionization

M-S-A® Gas Chromatograph

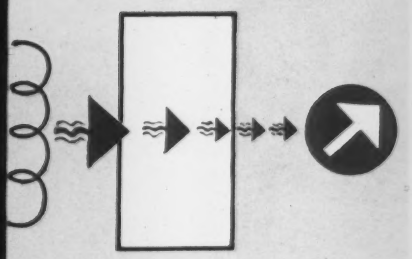
M-S-A® LIRA® Infrared Analyzer Model 200

M-S-A® LIRA® Infrared Analyzer Model 300

M-S-A® BillionAire* Analyzer

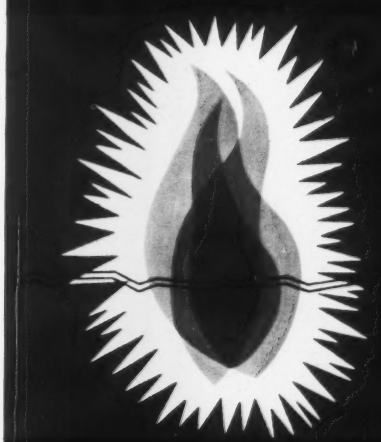
M-S-A® Process Refractometer

Depolarization

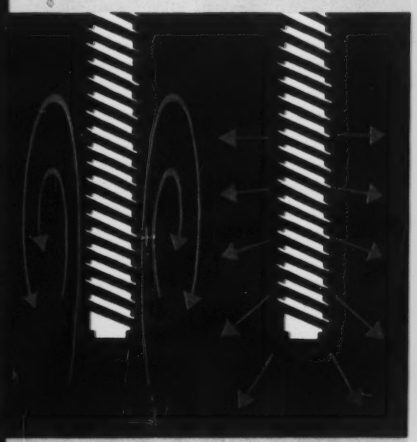


Infrared Analysis

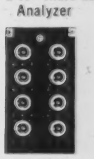
M-S-A® Inert Gas Analyzer



Catalytic Combustion

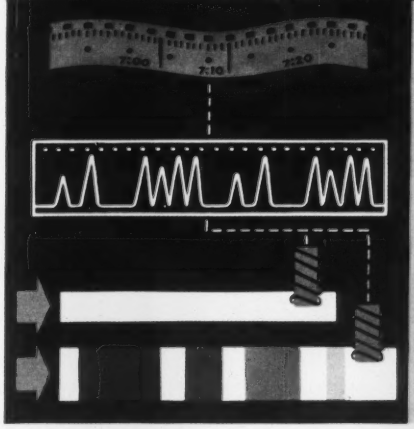


Thermal Properties



M-S-A® Combustible Gas Analyzer

M-S-A® Thermatron Analyzer

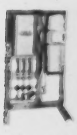


Chromatography

INSTRUMENT DIVISION
Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania

MSA

M-S-A® Oxygen Indicator



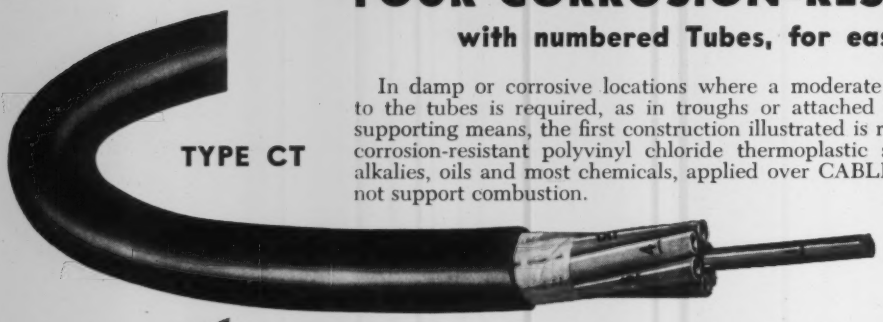
M-S-A® Water Vapor Recorder

*Trademark

CRESCENT ARMORED MULTITUBE*

FOUR CORROSION-RESISTANT TYPES

with numbered Tubes, for easy identification

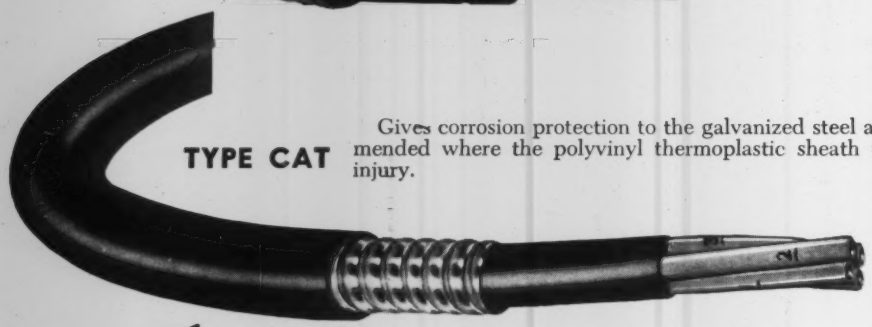


TYPE CT

In damp or corrosive locations where a moderate degree of mechanical protection to the tubes is required, as in troughs or attached to sheltered building surfaces as supporting means, the first construction illustrated is recommended. It employs a tough, corrosion-resistant polyvinyl chloride thermoplastic sheath, resistant to water, acids, alkalies, oils and most chemicals, applied over CABLED copper tubes. The sheath will not support combustion.

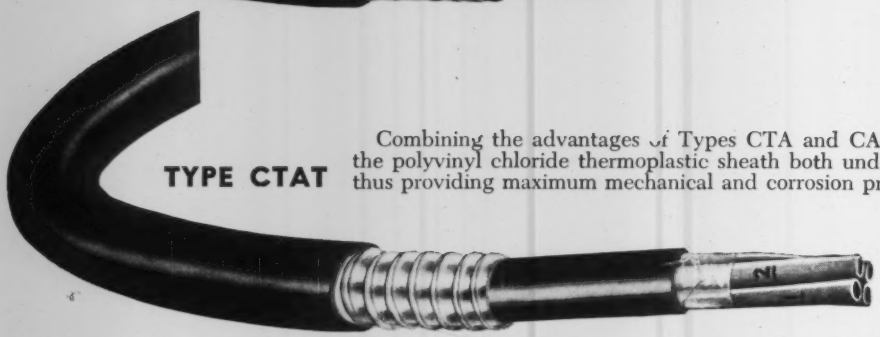
TYPE CTA

Gives corrosion protection to the tubes, and the galvanized steel armor protects the tubes and polyvinyl thermoplastic sheath from mechanical injury during and after installation. Recommended for direct burial in concrete or pulling into underground conduits.



TYPE CAT

Gives corrosion protection to the galvanized steel armor as well as the tubing. Recommended where the polyvinyl thermoplastic sheath will not be subject to mechanical injury.



TYPE CTAT

Combining the advantages of Types CTA and CAT, the fourth type illustrated has the polyvinyl chloride thermoplastic sheath both under the armor and over the armor, thus providing maximum mechanical and corrosion protection.

All these corrosion-resistant types can be furnished with copper, aluminum and polyethylene tubes, and up to 37 tubes.

Plastic Coated Single Tubes, copper or aluminum, should be used to give corrosion protection to all single lines up to the final tube fitting, where trouble from corrosion may occur.

Send for Bulletin 960-D giving complete information and engineering data

THIS PRODUCT IS LICENSED UNDER U. S. PAT. NO. 2,578,280

CRESCENT INSULATED WIRE & CABLE CO., INC.

TRENTON, NEW JERSEY

*Reg. Trade Mark

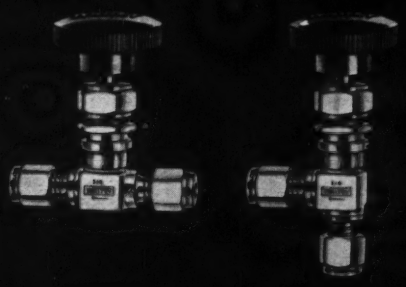
CIRCLE 67 ON READER-SERVICE CARD

← CIRCLE 66 ON READER-SERVICE CARD

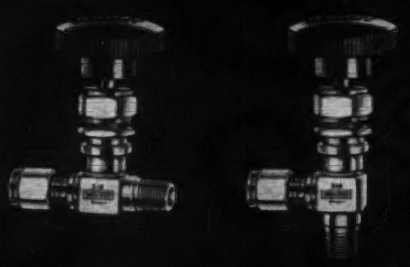
CIRCLE 28 ON READER-SERVICE CARD →

WHITEY MINIATURE VALVES

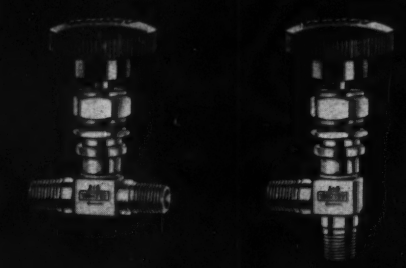
#0 SERIES VALVE



OVS2 OVS2-A



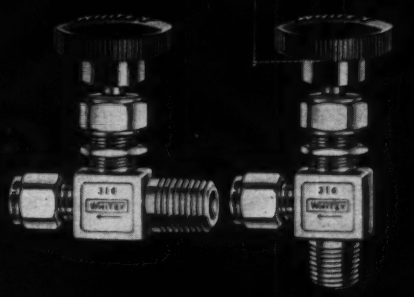
OVM2-S2 OVM2-S2-A



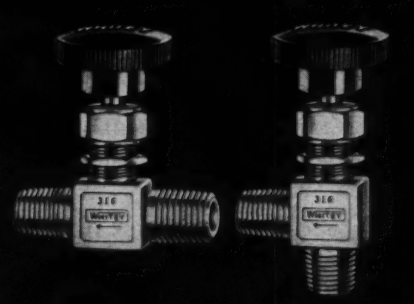
OVM2 OVM2-A

#1 SERIES VALVE

1VS4 1VS4-A

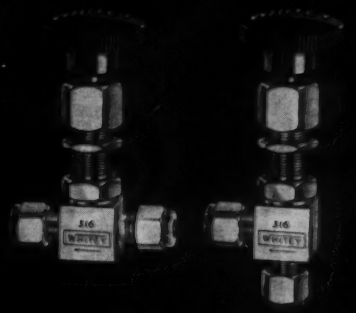


1VM4-S4 1VM4-S4-A

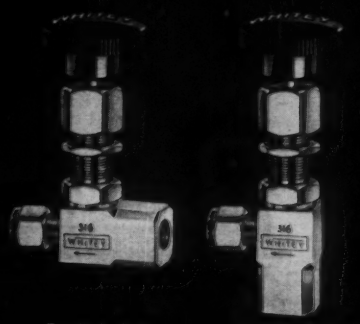


1VM4 1VM4-A

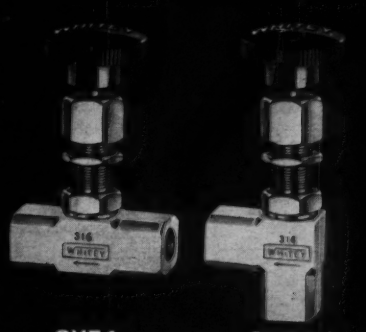
2 SERIES VALVE



2VS4 2VS4-A



2VF4-S4 2VF4-S4-A



2VF4 2VF4-A

WHITEY Research Tool Co. manufactures a complete stock of small valves designed for instrumentation work or any application demanding flawless performance in fluid or pneumatic systems.

The WHITEY Valves above illustrate some of the wide variety of connections available in ⅛" and ¼" pipe and tube sizes. These valves are stocked locally by your WHITEY Distributor.

In answer to customer demand, all WHITEY Valves through ½" size are available with Swagelok Tube Fitting Connections to facilitate ease of installation and positive, leakproof performance. Male and female pipe connections through ½" size are also available.

Panel mounting; Teflon* cylinder packing; micro-regulating and non-regulating stems are standard features on all WHITEY Valves.

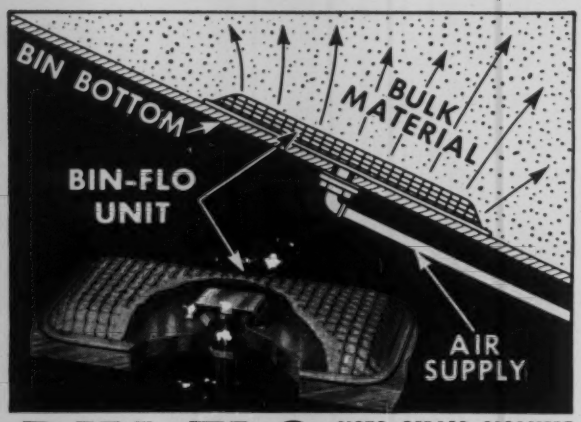
For color coding purposes, colored handles may be specified when ordering WHITEY Valves.

*Dupont

Complete technical data on WHITEY Valves available on request

FOR EXACTING SERVICE WHITEY

WHITEY RESEARCH TOOL CO. ● 5525 MARSHALL STREET ● OAKLAND 8, CALIFORNIA



BIN-FLO USES SMALL VOLUME OF AIR AT LOW PRESSURE

KEEPS BULK MATERIALS MOVING

BIN-FLO units in bins, chutes, hoppers, etc., restore flow characteristics to dry, finely ground materials which tend to pack or bridge in storage. Types for all materials and conditions. No moving parts; simple installation; negligible operating cost; no maintenance cost.

BIN-DICATOR the original diaphragm-type bin level indicator. In successful use for over 20 years. **ROTO-BIN-DICATOR** new, motor-driven paddle type; excellent on bins under pressure or vacuum, and for general application. Also explosion-proof units, U.L. listed.

THE BIN-DICATOR CO.
17190-B4 Denver • Detroit 24, Mich.

Write for detailed literature or phone TU. 2-3000

WE SELL DIRECT • PHONE ORDERS COLLECT

CIRCLE 69 ON READER-SERVICE CARD

WELDED
Diaphragm Seals

prevent corrosion or clogging of pressure instruments

Welding eliminates diaphragm leakage. Now available in a variety of designs and diaphragm materials for any application.

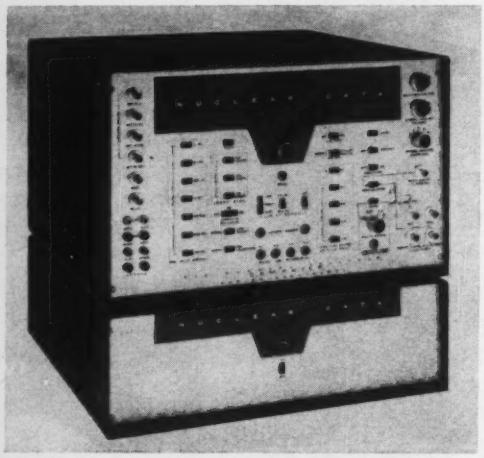
SEND FOR DESCRIPTIVE CATALOG 660

MANSFIELD & GREEN INC.
6185 Cochran Rd. • Cleveland 39, Ohio

CIRCLE 70 ON READER-SERVICE CARD

Analyzer-Computer

The series 130 analyzer-computer performs the energy distribution analysis of an "unknown" sample. By using standard spectra, or background measurements (previously made by this analyzer, or at other laboratories), it

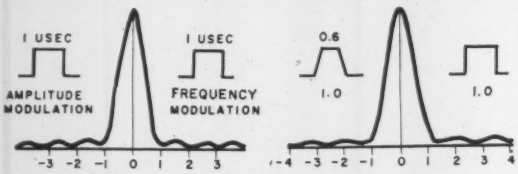


"dissects" the new information by subtracting a fraction of the standard spectra from the new information . . . The new information in "analyzed" (or read from a backlog of new tapes from other analyzers) into the first 256 channels of the memory, and the standard spectrum or background is read into the second half of the memory . . . The reduction proceeds step by step, until, in the judgment of the operator, the correct amount has been subtracted or added . . . (*From new* 4-*page brochure on Model ND*130, *Nuclear Data Inc.*, 3833 *W. Beltline Hy., Madison, Wis.*)

FOR THIS LITERATURE CIRCLE 261 ON READER-SERVICE CARD

Spectrum Analyzer Handbook

A spectrum analyzer is essentially a narrow-band superheterodyne receiver which is repeatedly swept in frequency over a selected portion of the radio-frequency band. At the same time, the horizontal deflection of the



spot on a cathode ray tube moves in synchronism with the sweep. The vertical deflection of the spot is proportional to the output voltage of the receiver. The resultant display is a plot of amplitude versus frequency over the radio-frequency band of interest . . . One of the chief uses of the spectrum analyzer is to check the operation of pulse-modulated transmitters. In particular, the spectrum analyzer may be used as a sensitive indicator of excessive frequency modulation during the pulse. Frequency modulation has the effect of broadening the spectrum; that is, removing power from the central lobe and placing excessive power into the side lobes . . . (*From new* 56-*page "Spectrum Analyzer Techniques Handbook," Polarad Electronics Corp.*, 43-20 34*th St., Long Island City* 1, *N. Y.*)

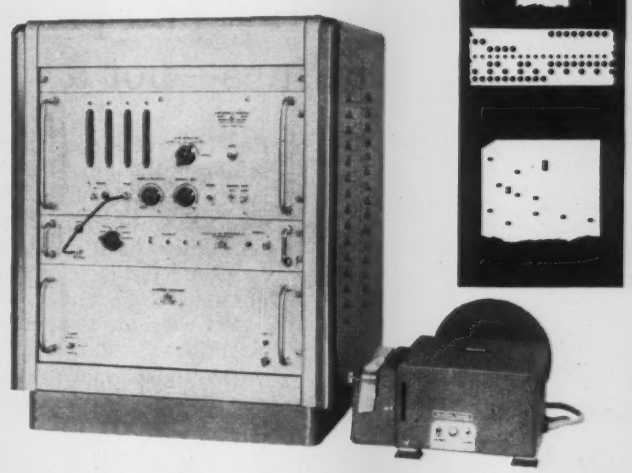
FOR THIS LITERATURE CIRCLE 262 ON READER-SERVICE CARD

Continued on page 2038

SIMPLIFY DATA HANDLING

with a low cost, flexible system that provides

- *fast, accurate measurement*
- *variable measurement rate and range*
- *typewritten, printed, punched tape or punched cards*



Dymec Model DY-5552 Data Processing System is a remarkably versatile tool for quickly accumulating data on a wide variety of physical, mechanical and electronic processes. Any phenomenon of nature or science that can be converted to a usable voltage or frequency can be measured and recorded through the DY-5552. Digital output can be in any form or combination of forms needed for further machine processing, visual analysis or transmission over any standard communication system. Applications are limited only by the imagination.

The moderately priced Dymec system consists of a voltage-to-frequency converter and electronic counter to convert input information to digital form, plus a scanner/coupler, which transfers this digital data and is capable of providing output for electric typewriter, Flexowriter, serial-entry adding machine and serial entry card punch or tape punch. In many cases two of these recording devices can be operated simultaneously. In addition, the system can drive a digital printer, such as the Hewlett-Packard 560A.

This is one of many Dymec Data Processing Systems which can be assembled from basic "building block" instruments. Versatile, flexible input scanners, counters, digital voltmeters, output couplers/translators meet a wide range of needs for speed, multiple input application, programming.

BRIEF SPECIFICATIONS	
Input Ranges:	0 to 1 v dc, 0 to 10 v dc, 0 to 100 v dc, 0 to 1,000 v dc (30% overrange permissible except on 1,000 v range; either polarity measured without switching). Frequency inputs, 1 cps to 120 KC. Gate times, 0.1 sec., 1 sec.
Accuracy:	DC inputs, .06%, ± 1 count Frequency inputs, .01%, ± 1 count
Operating Speed:	Controlled by Display Time Setting (variable from .1 to 15 sec. or indefinitely), maximum operating speed of 5 full scale readings per second.
Approximate price:	$3,600.00 (as pictured, including tape punch).

Data subject to change without notice. Prices f.o.b. Palo Alto

Describe your requirement today to your Dymec/Hewlett-Packard representative, write Dymec for further information or call Dymec direct. Extension 223 or 224.

DYMEC

A DIVISION OF HEWLETT-PACKARD COMPANY

7044

Dept. S-11, 395 Page Mill Road, Palo Alto, Calif. • Phone DAvenport 6-1755 (Area Code 415) TWX-117-U

CIRCLE 71 ON READER-SERVICE CARD

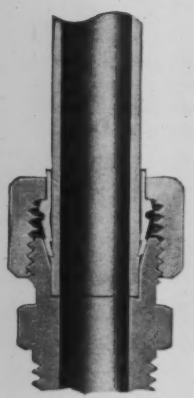
THESE PARKER TUBE FITTINGS MEET YOUR EXACT NEEDS

Instrumentation and processing call for specific fittings—not a "general" type

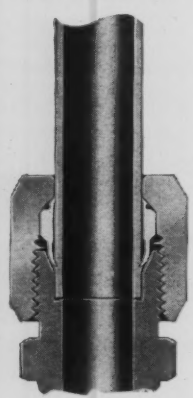
Parker covers *every* specific processing application with a fitting built for the job. There's inexpensive "Intru-lok" for instrument air . . . husky "Ferulok" for high pressures in steel and stainless steel. Both are positive, bite-type fittings. For complete corrosion resistance, new "Ridg-lok" is 100% of type 316 stainless.

Where flared tubing is used, the Parker 37° "Triple-lok" is the acknowledged leader, available in any practical metal.

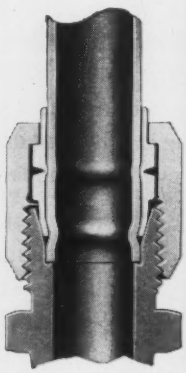
For extreme temperature conditions at any pressure, "Weld-lok" combines ease of assembly and streamlined flow. "Braze-lok" withstands somewhat less heat, but is even easier to assemble and can be disassembled when necessary.



FOR INSTRUMENT AIR, use "Intru-lok®" brass and aluminum tube fittings with the captive ferrule you can't lose. For copper, aluminum, Nylon and "Parker-POL" polyethylene tubing. Simple, compact, easy to install, inexpensive. Ask for Catalog No. 4324.

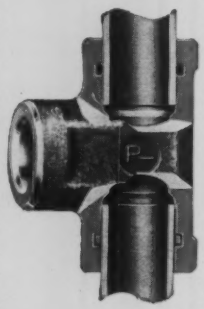


HIGH PRESSURES require "Ferulok®" heavy-duty flareless fittings with the visible bite that lets you make sure you have safe make-up. Usable with heavy-wall tubing. Excellent vibration resistance. Stocked in steel, stainless steel; available in Monel. Ask for Catalog No. 4320.

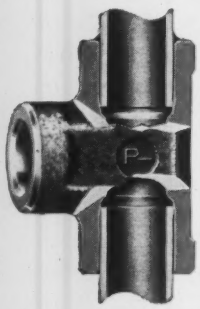


COMPLETELY CORROSION RESISTANT in stainless steel, "Ridg-lok®" has the added feature of a **REVERSIBLE FERRULE** which takes the gamble out of compression fittings assembly. Same design in brass, monel and steel. A special Teflon ferrule is available for use with glass tubing. Catalog 4323.

BRAZED JOINTS can be used where there isn't room to swing a wrench. They give you a permanent joint, yet one that can be taken apart and re-used. You just apply heat, either to make or break the joint. Parker "Braze-lok®" is completely reliable for high pressures at temperatures up to 500° F. Steel, stainless steel, Monel and cupronickel. Catalog 4375.



WELD WITH Parker "Weld-lok®" whenever a permanent joint will best serve your purpose . . . when the process is hazardous, when temperatures or pressures are extreme, when vibration is a problem. "Weld-lok's" socket design makes assembly easy. Steel and stainless steel in stock; aluminum available. Catalog 4370.



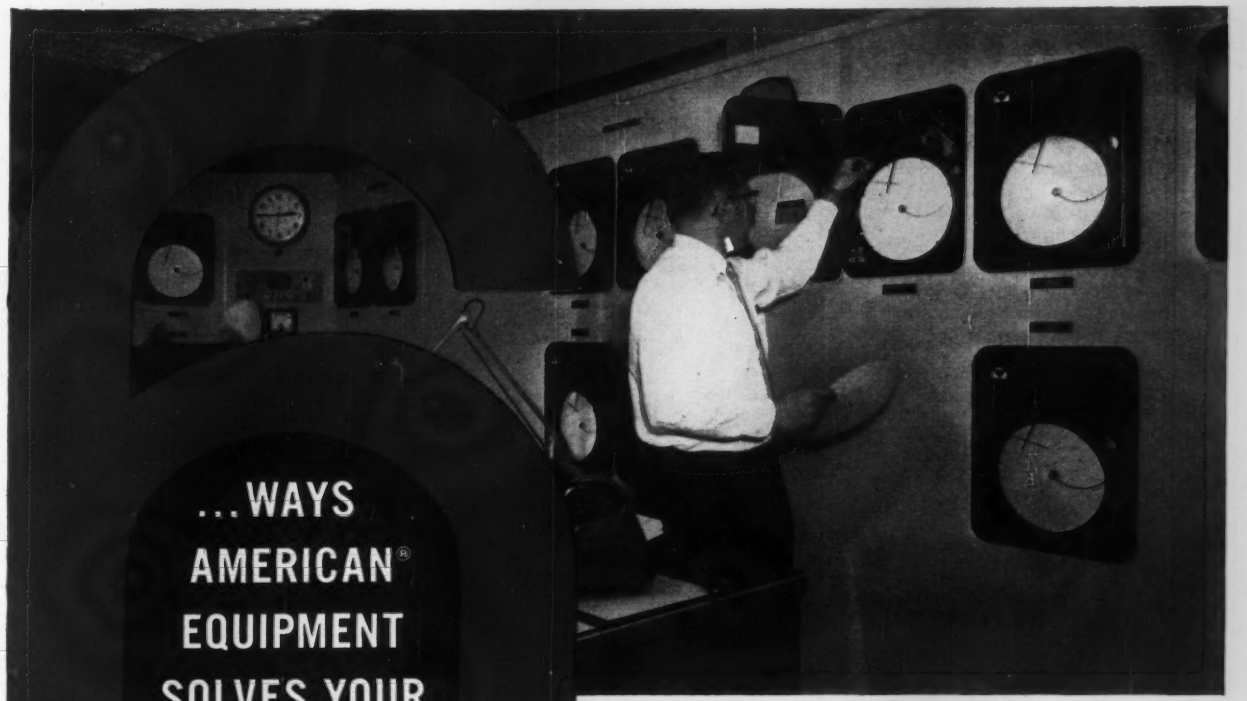
Complete specifications and engineering help are available from your nearby Parker distributor. Find him through the Yellow Pages, or write us direct.

PARKER-HANNIFIN

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue • Cleveland 12, Ohio
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS
EUROPEAN DIVISION • PARKER-HANNIFIN N.V. • SCHIPHOL • THE NETHERLANDS

3200-PHf

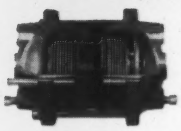
CIRCLE 72 ON READER-SERVICE CARD



...WAYS AMERICAN® EQUIPMENT SOLVES YOUR MEASUREMENT AND CONTROL PROBLEMS

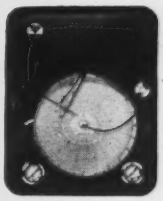
Whether your system is large or small, you can rely on American Meter's 125 years of engineering experience for the field-proven equipment you need for years of accurate, trouble-free measurement and control. Built to the highest standards of quality for sustained accuracy at lowest maintenance cost, American instrumentation reduces manpower requirements and provides continuous operating economies. Contact your nearest representative for complete details on how American equipment can build accuracy, dependability and economy into your system.

1 ORIFICE METERS



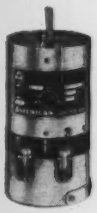
Dri-flo Orifice Meters in recording, indicating and integrating models assure maximum accuracy in differential pressure measurement.

2 CONTROLLERS



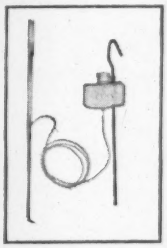
Series A-88 Controllers accurately control continuous process variables.

3 GASCLOK POWER DRIVE



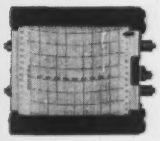
The ideal air or gas-operated instrument power drive and timing unit for remote installations.

4 CANNON METER PENS



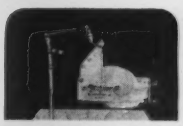
Controlled-flow meter pens prevent chart smearing and blurring. Record up to a year without refilling.

5 STRIP CHART RECORDER



Provides a long, unattended record with high resolution for accurate interpretation.

6 TELEMETERING SYSTEMS



Tone-frequency and multiplexed Telemetering Systems meet the individual requirements of any system.

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany • Atlanta • Baltimore Birmingham • Boston • Chicago • Dallas • Denver • Houston • Kansas City Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco Seattle • Tulsa • Wynnewood

IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Montreal • Regina • Vancouver

AMERICAN METER COMPANY

CIRCLE 73 ON READER-SERVICE CARD

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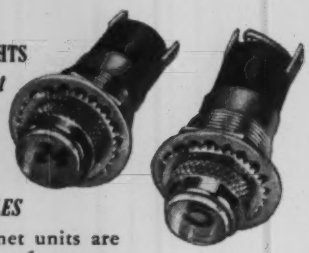
READOUT INDICATOR LIGHTS
No. 103 . . . *Incandescent*
No. 103N-022 . . .
Hi-Brite Neon



EASY TO READ
EASY TO ALIGN
CHOICE OF LEGEND STYLES

These miniature bayonet units are specially designed for fast, easy reading. A slip-fit shank makes it simple to line up the legend *after* the unit has been mounted on the panel. Several choices of inscription methods are offered; practical and least expensive for many applications is a printed disc behind a ½" flat glass lens. If this lens is colored, the legend is hardly visible until the lamp is lighted. Any legend may be used which fits within a 15/32" circle. DRAKE's exclusive *E-Z-Tite* knurl makes the units easy to install. Both Neon and Incandescent lamps for these units are regularly stocked by DRAKE.

DRAKE

★ ***SEND FOR DATA SHEET 602 WITH FULL DETAILS AND SPECIFICATIONS***

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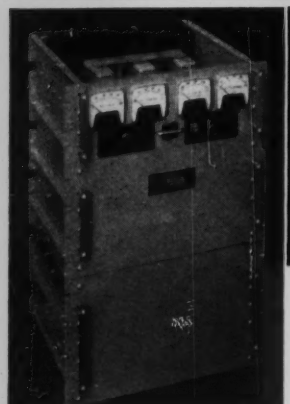
MINIATURE LIGHTING SPECIALISTS

CIRCLE 74 ON READER-SERVICE CARD



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STANDBY POWER SYSTEMS

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OPERATION OF MICROWAVE TRANSMITTERS

SWITCHLESS Load Transition
from primary to emergency power source

A-C POWER . . automatically applied to the load by the ELECTRO-PAC when the a-c line drops below a predetermined level. Ratings to 5 kva and higher.
Solid state circuitry, employing silicon controlled rectifiers eliminates moving parts.

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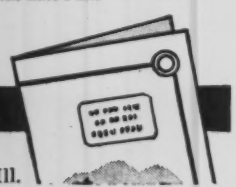
Write for your copy of this new engineering bulletin.

E—102



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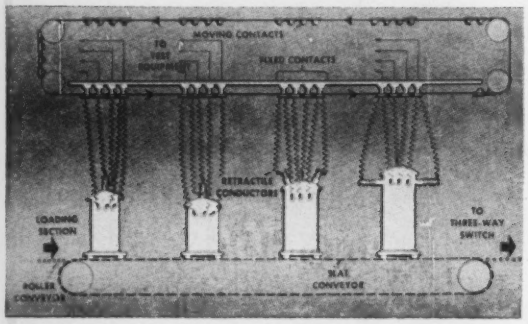
CORPORATION
946-F North Ave. . . Des Plaines, Ill.

CIRCLE 75 ON READER-SERVICE CARD

Card Programmed Sequential Control System

The schematic diagram indicates the conveyor arrangement to automatically test a variety of distribution transformer styles and sizes. All transformers pass through nine test stations. The entire procedure is programmed automatically from punched cards, one card for each transformer. Final test results are recorded on the same card which programmed the test.

Upon reaching the end of the conveyor line, each trans-



former is automatically marked by a color code spot to indicate one of the following: (a) Passed the test; (b) Failed the test; (c) Requires additional testing. This visual indication permits the operator at the discharge end to sort the units according to their next operation . . .

Each of the nine test stations has its own control system, all of which can be automatically operated from the master control console or manually operated from the individual control stations. This feature permits individual direction of each test, and facilitates the stopping of one test sequence without interrupting operation of the entire test facility . . .

The Company holds patents on digital circuit modules, which were originally designed for Drexel's own use in low cost, high reliability industrial systems. This line will offer a wide selection to the system designer interested in minimum cost design. Included will be transistor and diode gates, flip-flops, multi-vibrators, drivers, card cages and a selection of special purpose cards to satisfy recurring needs . . . (*From new* 12-*page "Annual Report,* 1960," *Drexel Dynamics Corp., Maple Ave., Horsham, Pa.*)

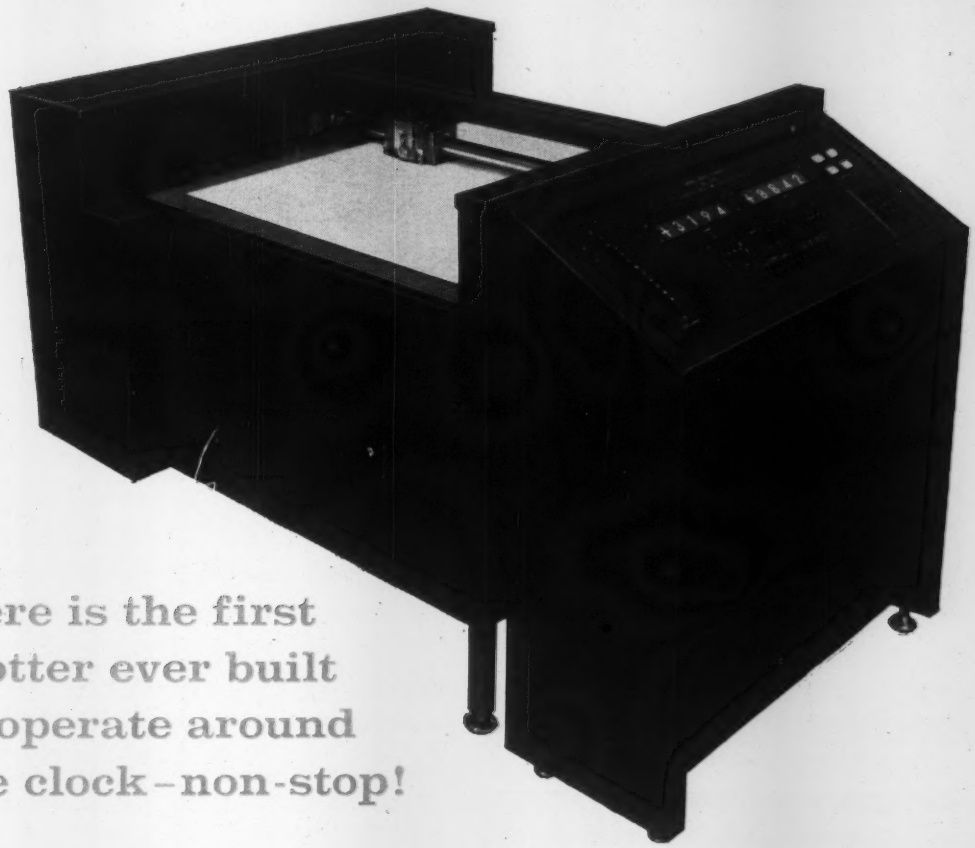
CIRCLE 263 ON READER-SERVICE CARD

Pressure Converter Rule

(*From new Slide Rule with pressure conversions and temperature conversions, Allegany Instrument Co., Div. of Textron Electronics Inc.,* 1091 *Wills Mountain, Cumberland, Md.*)

CIRCLE 264 ON READER-SERVICE CARD

UNPRECEDENTED RELIABILITY!



Here is the first plotter ever built to operate around the clock–non-stop!

Sure, Gerber's new plotter is as accurate as any you've ever seen. Plots to ±.002". Repeats to ±.001".

But even more important, the Model GP-30-D operates at pinpoint precision 24 hours a day, seven days a week. No inaccurate plots, no need for test decks every few hours. Absolutely no drift.

In short, the GP-30-D will plot your data as fast and as long as your computer turns it out!

And reliability is just one of the many new features built into this new plotter. Here are a few more:

Maximum slewing speed: 20" per second.

Plotting speeds:
- 50 points per minute with points spaced up to 4½" apart from IBM cards.
- 42 points per minute when plotting at random.
- 80 points per minute with paper tape input.

Digital Logic: No digital to analogue conversion used. The digital logic is all solid state, plug-in cards, which actually make up a special purpose computer.

No potentiometers: Magnetic-type discreet shaft encoders eliminate all drift and warm-up time.

Drive system: Precision ball screws driven by ¼ hp. motors.

Choice of tables: Plotter available with a vertical table as well as the horizontal table shown.

For plotting accuracy and reliability, there is no "or equal." Write for full details.

See this all-new plotter at Booth No. 105-106 of the Eastern Joint Computer Conference, Dec. 12-14, Sheraton Park Hotel Washington, D.C.

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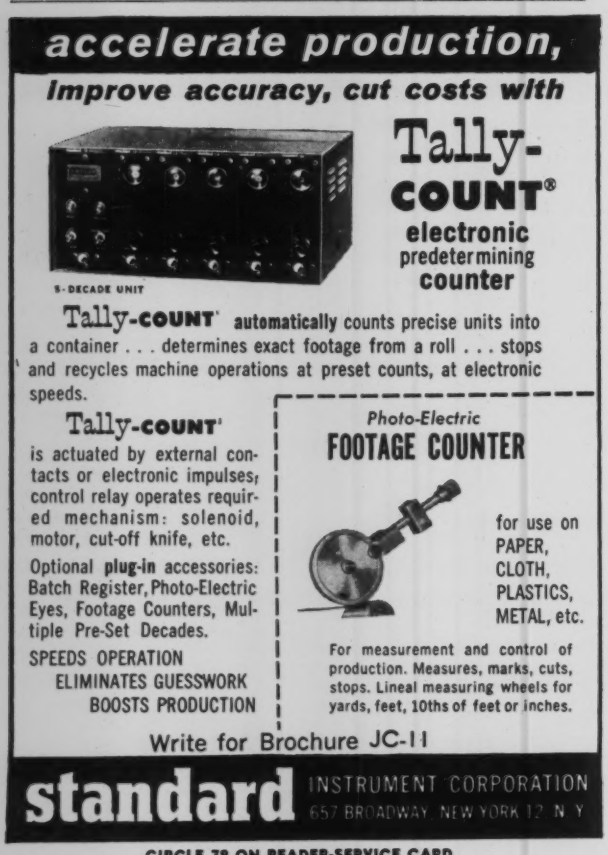
accelerate production,
Improve accuracy, cut costs with
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Tally-COUNT automatically counts precise units into a container . . . determines exact footage from a roll . . . stops and recycles machine operations at preset counts, at electronic speeds.
Tally-COUNT is actuated by external contacts or electronic impulses; control relay operates required mechanism: solenoid, motor, cut-off knife, etc.
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SPEEDS OPERATION
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for use on PAPER, CLOTH, PLASTICS, METAL, etc.
For measurement and control of production. Measures, marks, cuts, stops. Lineal measuring wheels for yards, feet, 10ths of feet or inches.
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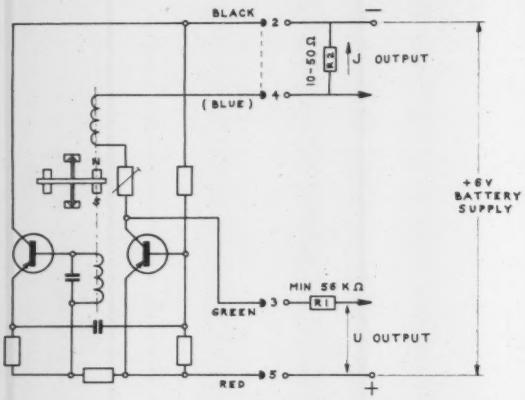
CIRCLE 78 ON READER-SERVICE CARD

Timing Pulse Generator

Mechanical and electronic sections of this d-c pulser reciprocally control one another to produce a low-frequency periodic pulse output with a stabilized precision of 3×10^{-5} per 24 hours. Standard frequencies can be set at factory to 4, 5, or 10 pps., 4.5 volts.

A spring balance wheel starts to oscillate when current is switched on. Two fixed coils are disposed coaxially



above and below a permanent magnet set in the rim of the balance wheel, parallel to its axis of rotation. The current induced in one of the coils when the magnet passes triggers the transistor amplifier. The magnetic field induced in the other coil by the amplifier acts on the magnet and gives the balance wheel an impulse to maintain oscillation. The coaxial arrangement of the coils results in pulses independent of the direction of approach of the magnet. Output pulses, two for each complete oscillation, are therefore almost equally spaced. There are two adjusting levers, one fine, one coarse, for regulating the period. A potentiometer regulates the amplitude of oscillation.—Price $17.50. (*From new flyer, Presin Co., 2014 Broadway, Santa Monica, Calif.*)

CIRCLE 265 ON READER-SERVICE CARD

Brushless DC Motor

The Brushless DC motor is a device which has been desired by industry for many years. Such a device has been developed and is in production at Astro Dynamics, Inc., Burlington, Mass. The Brushless DC Motor has numerous advantages which are as follows:

1. Eliminates electrical noise when operating.
2. Eliminates acoustical noise.
3. Eliminates arcing problems that are encountered at high altitudes.
4. Eliminates the use of bulky ac supplies.
5. Reduces maintenance requirements.
6. Increases the longevity of the device.
7. Displays a wide variation of speed control characteristics.
8. Retains the simplicity of an ac device.
9. Increases reliability.

. . . (*From new brochure, "Brushless DC Motors", Astro Dynamics, Inc., Northwest Industrial Park, Burlington, Mass.*)

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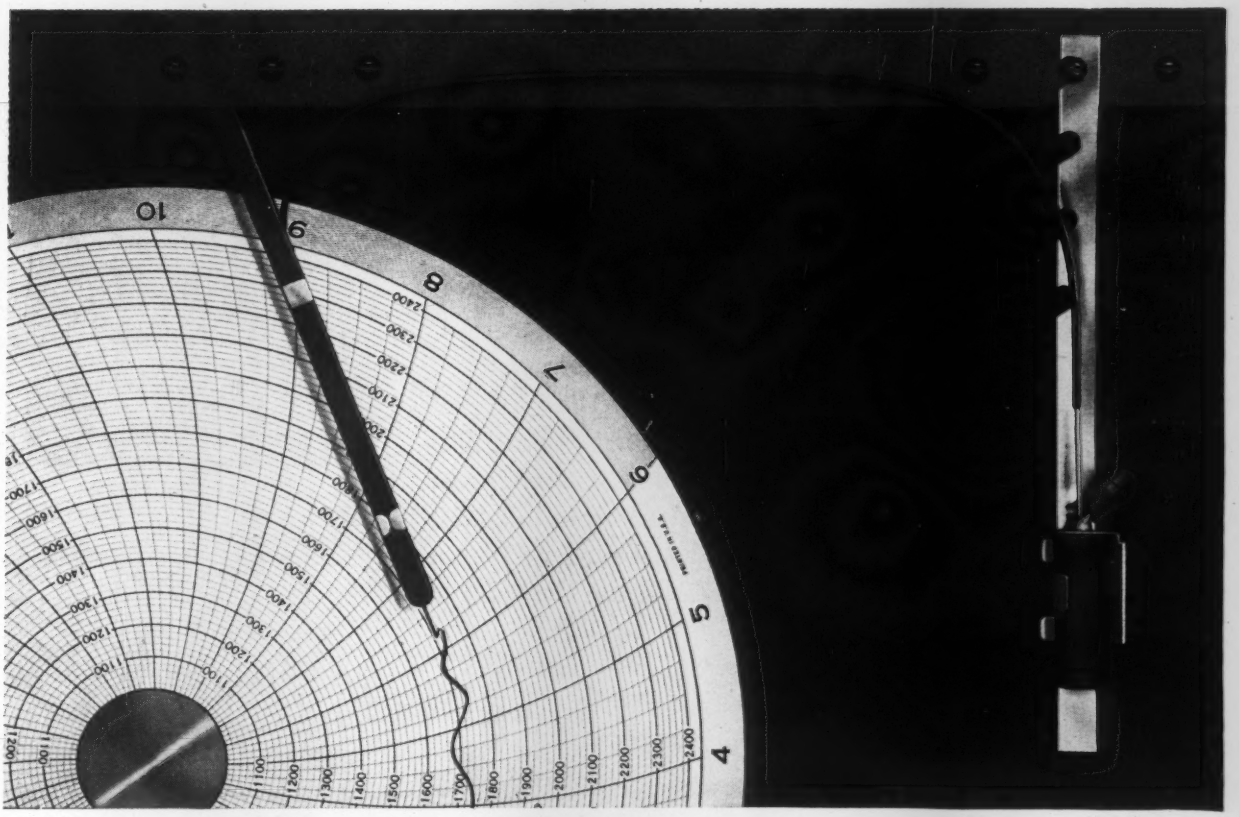

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NEW MARK-TROL*

eliminates 95% of the mess and maintenance of round chart recorder inking systems . . .

In 10 minutes, convert present markers with Mark-Trol, a completely sealed capillary system with replaceable ink cartridge . . . adaptable to 90% of all round chart recorders in service today.

Esterbrook's Mark-Trol is a completely new concept in marking systems. Because of its universal design, you can eliminate the messy problems inherent in most round chart inking systems in use today. Because maintenance is reduced to little more than routine inspection, Mark-Trol will pay for itself in a matter of days.

Sealed system eliminates dust, dirt, moisture and mold which clogs open-bucket devices. Operation is thoroughly efficient regardless of location, inside or out, under service conditions of humidity, precipitation, chemical fumes or other foreign matter, and over a wider temperature range —0°F to 145°F. Slip-in, disposable, sealed ink cartridge means ink is never directly handled . . . no messy suction tubes, syringes, droppers; no reservoirs to clean out. Eliminates breakage of plastic bags or glass devices. The cartridge contains a large supply of ink, extending your change cycle from days to months . . . and then in a matter of seconds the cartridge is replaced.

ORDER ONE FOR TRIAL—Mark-Trol has been field-tested for 2½ years—extensively in the power and processing fields. We invite you, however, to make a trial installation of your own with a Mark-Trol unit. Send us the coupon today.

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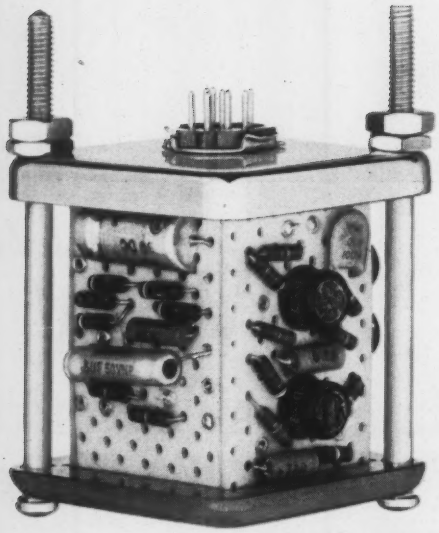

This is the smallest, most accurate, pressure-sensitive potentiometric transducer in existence today. It is the most recent example of DeJUR's ability to deliver precision transducers for measuring pressure, flow, acceleration, temperature and other parameters to your exact specifications.

UNITS SHOWN ARE ACTUAL SIZE

By building this solid-state digital converter around the transducer, DeJUR produces a self-contained, digital pressure transducer. For specs, write: Instruments Division, DeJUR-Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y. ■ You're always sure with DeJUR

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Write for free 8-page technical brochure on the "Universal Digital Transducer."

CIRCLE 82 ON READER-SERVICE CARD

M. H. ARONSON . . . editor

"THE AWESOME SERVANTS"

ON the evening of October 31, Bell & Howell Corporation (of which Consolidated Electrodynamics Corporation is one Division) sponsored a nationally televised documentary program—"The Awesome Servants"—which took a penetrating look at automation and its effects on the economy—particularly unemployment. Congressmen, business men, union representatives and individuals who were concerned with automation were interviewed on the subject, and the result was a forceful portrayal of the problems of each individual interviewed, which might be stated as follows:

Legislator: Production is up—but so is unemployment: more persons enter the labor market each week than are employed. A serious problem exists.

Businessman: There is no alternative to automation—to remain competitive in a competitive economy you must use the most effective devices available, including automation. Not to do so means loss of your market—if not to another American, then to a foreign competitor, thus creating more unemployment.

Worker: Our plant now produces more with fewer persons. We (or my friends) have been thrown out of work by automation. We workers deserve the benefits of automation as well as the company—instead we are getting unemployment.

The major impact of the program came from the interviews with worker after worker who had been thrown out of work—by automation. Factory after factory was shown which had increased its efficiency via automation—and the workers laid off in the process were shown in their misery and fear, emotions which came through the screen much more vividly than the statement by an industry spokesman: "History shows that technological progress creates jobs."

Another fearful climax was reached when the awesome power of the computer was shown in terms of the clerical jobs that will soon be threatened by this yet-early form of automation.

Bell & Howell is to be congratulated for a magnificent job of looking at the problem—but we suggest that this TV program

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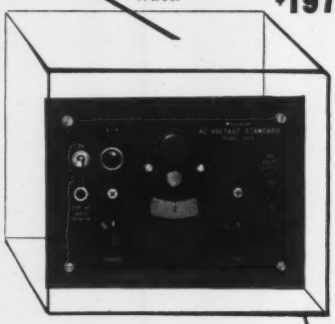
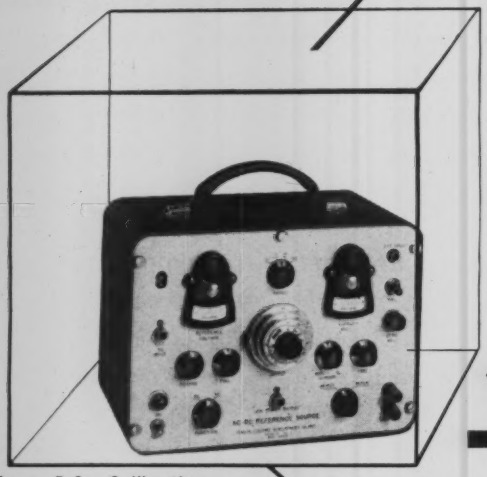
INCREMENTAL ANALYZER
Convenient measurement, monitoring and recording of incremental changes in any parameter. **$250.**

MODEL 6010
A.C. VOLTAGE STANDARD
An A.C. Standard Cell; 100 Volts RMS at 0.1% absolute accuracy. Available output power of 1 watt. **$197.**



MODEL 5890
PORTABLE REFERENCE SUPPLY



A.C. - D.C. Calibration source; Any voltage from .01 to 100 Volts at up to 10ma. ± 0.25% absolute accuracy at any set voltage. **$495.**

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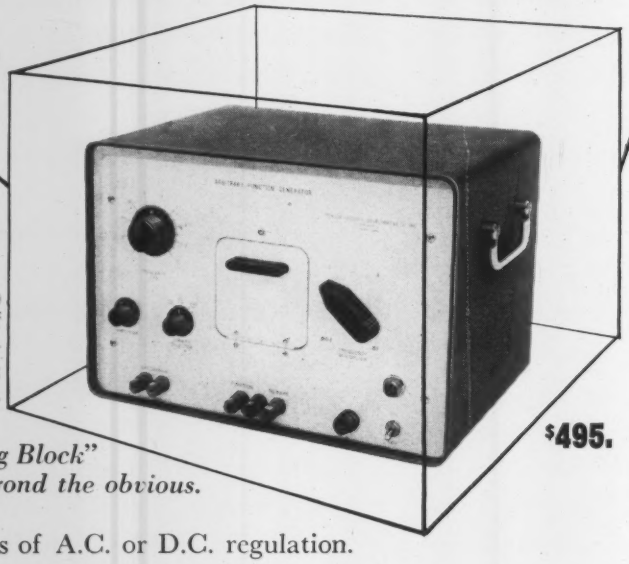
Very low frequencies, .001 to 10 cps; mechanical rotation of a custom built cam can produce a variety of waveforms; sine wave, ramp function, etc.



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Each of these instruments is a true "Testing Block" since there are important applications beyond the obvious.
ie:

5880 can provide expanded scale displays of A.C. or D.C. regulation.

5890 can be used as a true potentiometric A.C. and D.C. digital voltmeter.

6010 used with a ratio transformer becomes an 0.1% A.C. digital voltmeter.

5846 offers either a D.C. function or a suppressed carrier output modulated at the function frequency.

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CIRCLE 81 ON READER-SERVICE CARD

suffered from the same confusion between cause and effect that has been characteristic of all such discussions for years. We present an editorial on this cause-effect relationship, published in *INSTRUMENTS AND CONTROL SYSTEMS* in 1955, at a time when the instrument-industry spokesmen were claiming that automation was responsible not only for the prosperity being enjoyed at that time but for the inevitably greater prosperity of the future.

Automation and Economics—

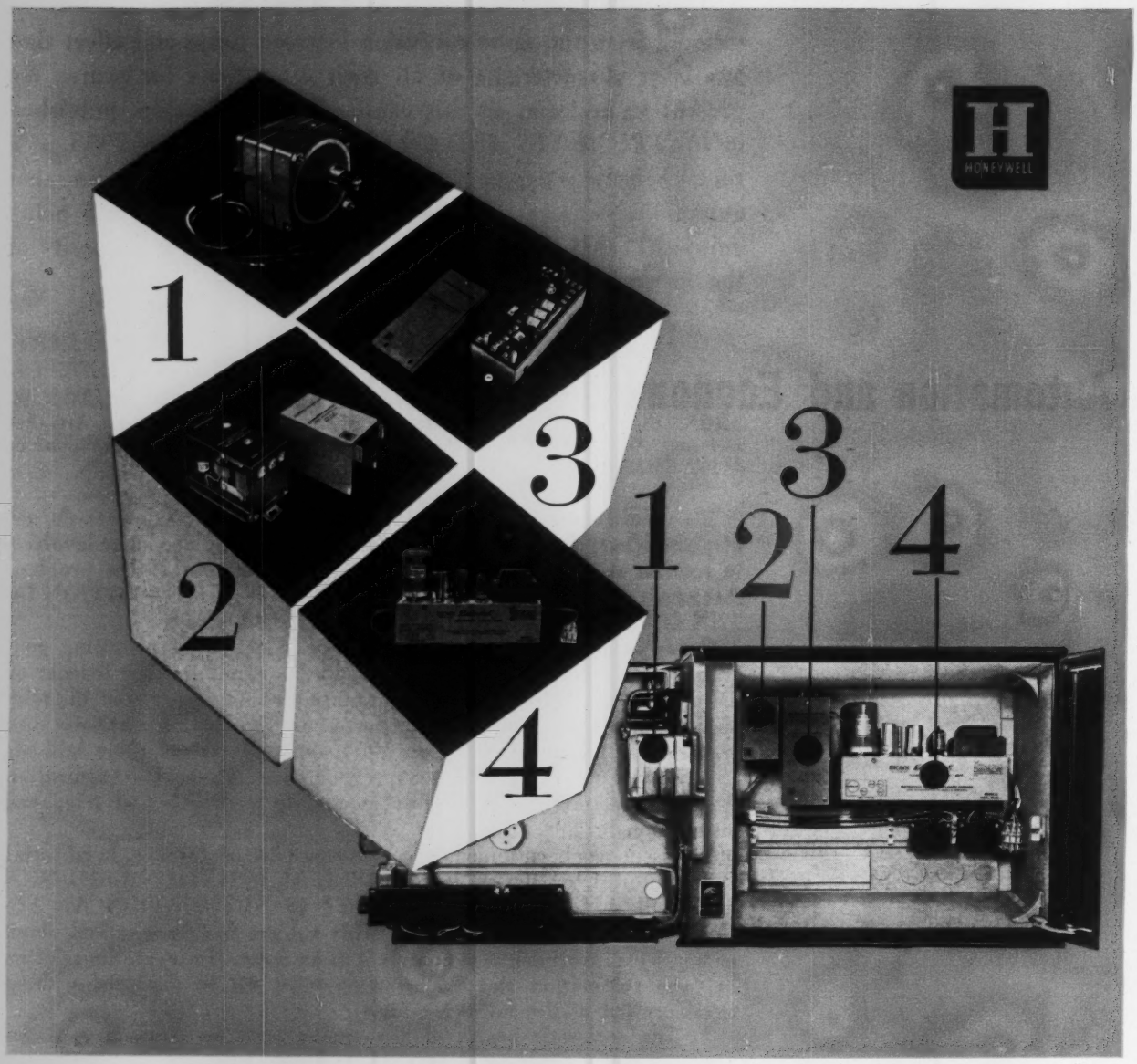
abstracts from a talk presented by MILTON H. ARONSON before the Annual Meeting of the American Industrial Arts Association, Atlantic City, N. J., April 27, 1955, and reprinted as an editorial in *INSTRUMENTS AND CONTROL SYSTEMS* magazine at that time:

We do not mean to try to establish that automation devices do not displace labor; they are designed particularly to displace labor involved in routine, onerous, dangerous, menial and trivial tasks. The problem that needs discussion is WHAT IS THE ROLE OF AUTOMATION IN THE OVER-ALL ECONOMIC PICTURE?

Today's economic problems cannot be disposed of by citing generalities, by pointing out long-term trends, by reminding the listener of the buggy-whip industry, by simple platitudes. The growth of the telephone industry since the introduction of the automatic telephone dial system does not answer why, in 1954, the Bell system alone laid off 17,000 workers (according to Joseph Beirne, Pres., Communication Workers of America-CIO) while expanding its number of telephone installations.

The issue has been joined, in conference after conference, in editorial after editorial, on the subject of WILL AUTOMATION CREATE A SICK OR A HEALTHY ECONOMY? IS AUTOMATION AN ECONOMIC BOON OR BURDEN? This subject has been talked about so much that everyone now accepts it as an issue. However, the relation between automation and the economy must not be analyzed without consideration of the following facts:

1. The economic health of any nation rests on economic policies that include tax rates and policies, federal expenditures, price/wage ratios, bank policies and interest rates, stock values and dividends, and other economic factors.
2. These economic factors establish the degree of purchasing power and market demand—which in turn establishes the degree of consumption of the output of an economy.
3. Automation is but one of many technological developments leading to increased productivity.
4. A healthy economy will consume its productive output and retain still greater demand with unemployment near the inevitable minimum of a few percent of the total workforce available.
5. A sick economy has economic troubles, with or without automation. These economic ills include inability to consume the output of the economy, growing inventories, and growing unemployment. These symptoms now exist.
6. Sickness in the economy must be attacked at its sources—which are the *economic factors* that establish the purchasing power of the people in the country. The only alternative to increasing purchasing power is to decrease productivity, a reactionary and dangerous approach which few advocate.



It's what's in the modules that matters!

Take the newly designed modules in ElectroniK 15 Potentiometers. These modules have operating and servicing features that represent the very latest developments in the art of reliable instrumentation—**1.** Sectionalized motor module makes servicing a snap. Any major part of the servo or chart drive motors can be replaced in a matter of minutes. **2.** Line-powered constant voltage module provides a completely automatic d-c voltage source and replaces batteries, standard cells, and standardization mechanisms. **3.** Quick-change measuring circuit module reduces range or actuation changes to simple screwdriver operation. **4.** Quick-connect amplifier module is easily removed for servicing. Over 15 models available—for gain up to 40 x 10^6, for input impedance of 400 to 50,000 ohms.

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CIRCLE 80 ON READER-SERVICE CARD

These few facts show clearly that automation cannot establish the basic economic health of the nation—although it might, conceivably, aggravate economic ills by increasing productivity at a time of economic decline (i.e., time of diminished or inadequate purchasing power).

Hence, automation has no direct economic implications. It cannot make an economically sick country healthy or an economically healthy country sick. It can make a healthy economy still more healthy and it might conceivably make a sick economy more sick—but it cannot be a fundamental cause for economic stability or instability. It is a catalyst, not a cause.

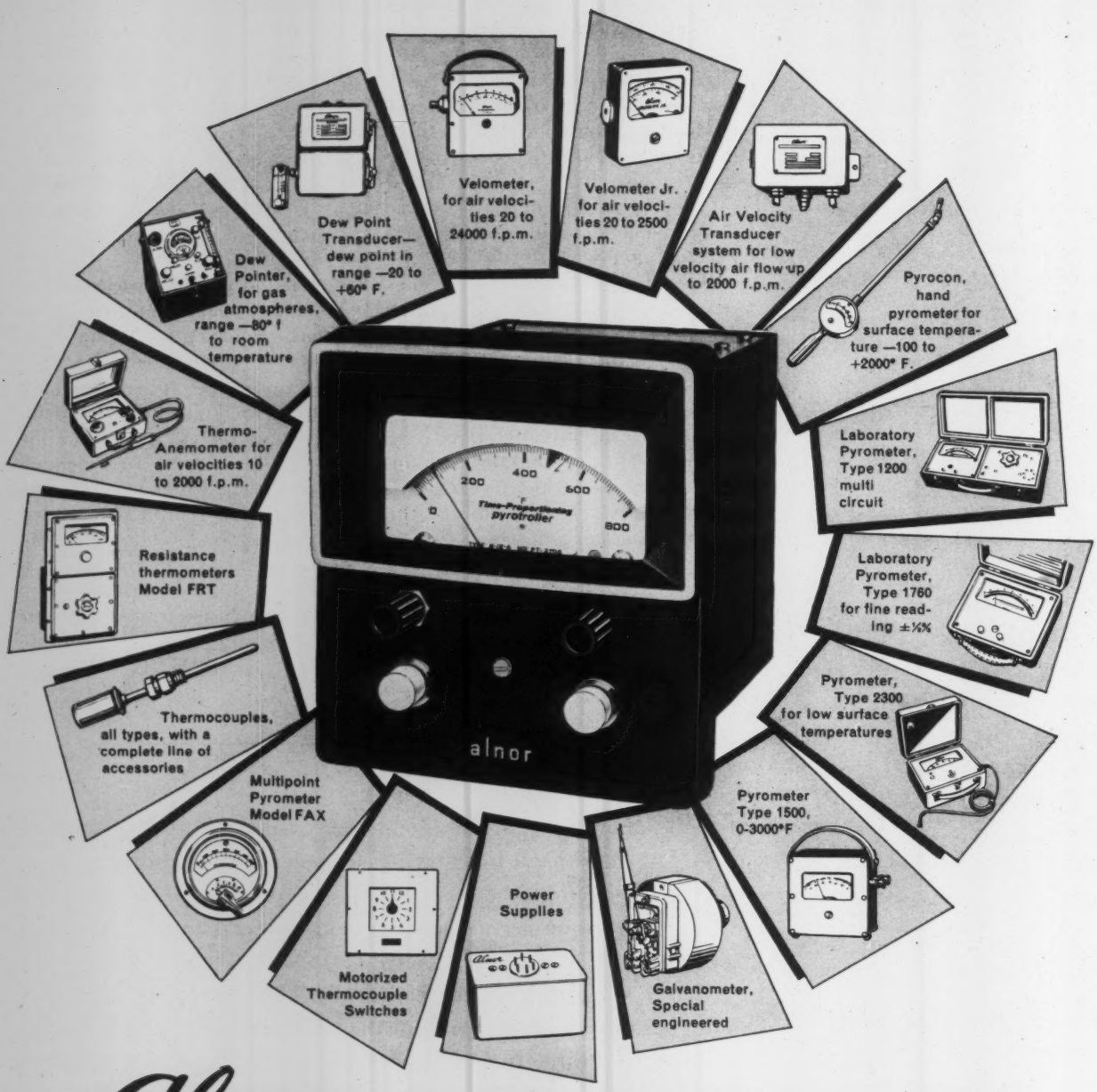
Therefore, when economic maladjustment occurs or threatens, the *cause* must be sought in the inter-related action of the many economic factors that together establish the purchasing power of a populace. These are the factors that need investigated and analyzed, and such investigation would be a constructive and appropriate subject for anyone interested in the economic effects of any technological development.

Conversely, investigations of automation and conferences on the economic effects of automation are fruitless and essentially antimachine-type activities—which everybody deplores piously while participating energetically. They waste the time and effort that should be directed at the economic causes of the economic subject under consideration. Even worse, they are leading to the development of automation as a scapegoat, a whipping boy. We in the automation field must refuse to permit ourselves to be considered as the economic determinates in our economy, we must counterattack and insist on solving economic problems at their economic roots.

The above is more pertinent today than it was 6 years ago. The instrument industry has a special responsibility to those made unemployed when plants are automated; we must not avoid it or evade it with self-righteous appeals to efficiency and progress.

Every technical worker has a special responsibility also—if only because more than half of the technical force of the country is supported directly by the government via its gigantic military efforts. In this sense the technical work-force of the country, the group perhaps best able to fend for itself in an open market, is today the recipient of the subsidy of the state. It ill behooves anybody receiving the annual benefits of $48 billion of Federal expenditures for defense to say that the Federal government cannot afford to retrain, re-educate, relocate and re-employ those few percent of our country now unemployed—many because of the "awesome servants."

Milt Aronson


Velometer, for air velocities 20 to 24000 f.p.m.
Velometer Jr. for air velocities 20 to 2500 f.p.m.
Air Velocity Transducer system for low velocity air flow up to 2000 f.p.m.
Pyrocon, hand pyrometer for surface temperature —100 to +2000° F.
Laboratory Pyrometer, Type 1200 multi circuit
Laboratory Pyrometer, Type 1760 for fine reading ±½%
Pyrometer, Type 2300 for low surface temperatures
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RAY SAWYER*
The Perkin-Elmer Corporation

Absorption Spectrophotometry

Instrumental analysis has made its greatest advances over the past ten or fifteen years in the field of absorption spectroscopy. This technique involves passing radiation of different wavelengths through a substance and measuring the radiation absorbed or transmitted to determine the material's identity, concentration and molecular structure. This begins an I&CS series on analytical techniques.

IN 1800 Sir William Herschel, while conducting a series of experiments to determine the distribution of heating power among the various colors in the solar spectrum, discovered that the heating power increased towards the red end of the spectrum and did not reach a maximum until the detector, a sensitive thermometer, had been moved beyond the limit of the visible spectrum. Thus was discovered a form of radiant heating energy which is refracted by a prism (to a lesser degree than red light) and to which the eye is insensitive. Herschel demonstrated that this radiation is reflected and refracted according to the laws of optics.

Little progress was made following Herschel's experiments until Sir John Herschel continued his father's work and attempted to develop photographic and other methods to make the infrared spectrum visible.

By 1860, many investigators were engaged in establishing the long-wave limit of the infrared spectrum. Müller placed the limit at approximately 1.9 microns. In the 1876-1880 period, the infrared spectrum had been measured to 7 microns by means of optical interferometry. In 1897, the infrared spectrum had been extended to 20 microns, and the following year to 150 microns. In 1920, with the development of Hertzian oscillators, the infrared spectrum study was extended to almost 1000 microns. It is now usual to set the long-wavelength limit of the infrared spectrum to 200 microns. Thus the infrared spectrum extends from 0.70 micron to 200 microns, covering a large portion of the electromagnetic spectrum (Fig. 1).

*Mr. Sawyer is now with Columbia University.

Absorption Spectroscopy

Instrumental analysis has made its greatest advances over the past ten or fifteen years in the field of *absorption spectroscopy*. This technique involves successively passing radiation of different wavelengths through a substance and measuring the radiation absorbed or transmitted to determine the material's identity, concentration and molecular structure.

With this technique, chemists have the means to identify and measure organic and inorganic chemicals with speed.

The ultraviolet region (Fig. 1) extends from 0.2 μ to 0.4 μ; visible from 0.4 μ to about 0.7 μ; and infrared, from 0.7 μ to about 200 μ (the IR region most useful in chemical analysis is from 2.5 μ to 15 μ). Another

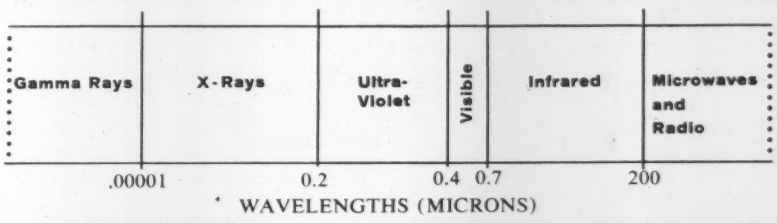


FIG. 1. ELECTROMAGNETIC SPECTRUM. Infrared region is from 0.7 to 200 microns.

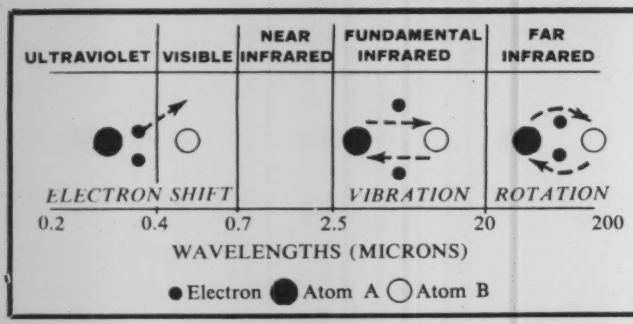


FIG. 2. TYPES of vibration and rotation of electrons and atoms. Ultraviolet radiation causes electron shifts. Infrared radiation causes molecular vibration.

subdivision of IR is the near-infrared, extending from 1 μ to 3 μ.

This division of the electromagnet spectrum is based on the methods for producing and measuring radiations of the wavelengths represented by these various regions, and on their interaction with matter. There are no sharp boundaries between these regions. Consequently, problems involving absorption of radiation in the transition zone between adjacent regions can often be solved by instruments designed for either adjacent region.

How IR, UV and Visible are Related to Structure

The value of absorption spectroscopy in chemical analysis lies in the fact that matter absorbs radiation very selectively with respect to wavelength. This relationship can be understood by considering the effect of different kinds of radiation on the molecular structure of compounds.

All molecules are made up of atoms connected by electromagnetic bonds. These atoms are in continuous motion, vibrating and rotating about their center of gravity. Contributing to the electromagnetic bonding forces holding a molecule together are valence electrons shared by the atoms comprising the molecule.

The atoms of each molecule vibrate at a definite frequency with respect to each other. This frequency is specific to its molecular structure. If radiation of a given frequency (wavelength) strikes a compound which has the same vibration frequency, this radiant energy may be absorbed by the molecule, increasing its natural vibration. However, if radiation of some other frequency strikes the compound, it passes through the molecule without change in radiant energy. Since the *molecular vibrational* frequencies of substances (Fig. 2) have the same range of values as the frequency of infrared radiation, IR radiation can be used to characterize *molecular structure*.

The electromagnetic energy involved in electron bonding is of a much higher order than the infrared energy levels associated with the vibration of atoms (Fig. 2). It corresponds to the shorter-wavelength, higher-frequency electromagnetic radiations in the UV and visible range. Consequently, when molecules absorb UV and visible radiations, electrons undergo discrete energy shifts. Electrons participating in valence bonds may change energy levels and so may the electrons in inner shells. Since the electronic energy levels of a molecule are specific to it, the absorption frequencies causing such electronic transitions also can be used to characterize the molecule.

Applying these absorption phenomena to instrumental analysis involves irradiating a sample with all frequencies in a given region—in successive wavelengths—and recording those which are absorbed (Fig. 3). The instrument determines not only what compound is present, but also how much, since the amount of energy absorbed is a measure of the number of molecules present.

Each analysis is recorded as a graph of the energy transmitted *vs* the frequency or wavelength. This is the spectrum—IR, UV or visible—of the sample, and is a fundamental property of the sample which can be used both to characterize it and to determine its concentration.

Both IR and UV (UV and visible generally are grouped together) are widely used in chemical analysis.

Since the IR spectrum of an *organic compound* is its most characteristic physical property, it is generally selected where specificity is the prime requisite. IR can distinguish small differences in chemical structure, which show up as large differences in the IR spectrum to make identification of complex mixtures simple.

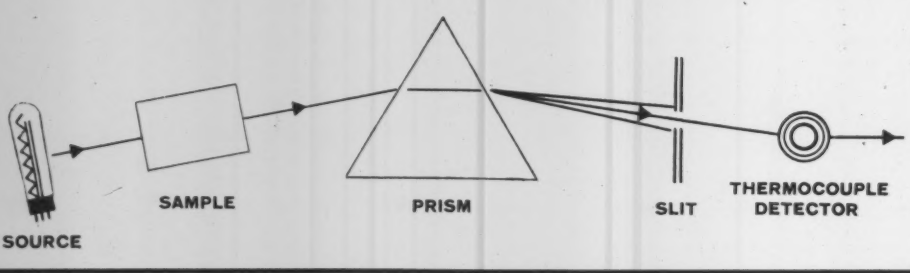


FIG. 3. BASIC SCHEMATIC of absorption spectrophotometry.

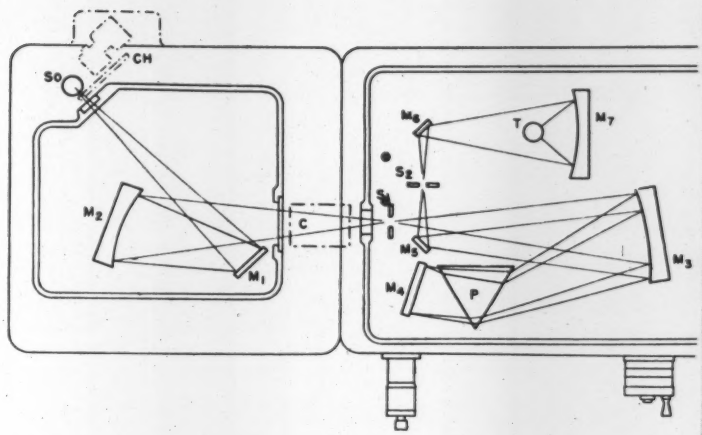


FIG. 4. OPTICAL SCHEMATIC of single-beam infrared spectrometer shows path of radiant energy from incandescent globar source (So) through the 13-cps motor-driven 180° opaque chopper (CH) to transfer mirror M_1, thence focussed through the sample cell (C) onto the entrance slit of the monochromator.

An off-axis paraboloidal mirror (M_3) collimates the radiation for a first dispersion by the salt prism (P). Littrow mirror (M_4) can be rotated slowly to reflect desired spectral interval back through the prism for a second dispersion, then refocussing by M_3 toward the flat exit mirror (M_5).

The near-infrared region is valuable for certain analyses. Near-IR instruments can be used to measure *water*, and, by operating at lower concentrations of material, to distinguish between groups such as NH and OH, which overlap in the conventional IR region.

UV is not as specific as IR, but it is a *more sensitive* technique. Moreover, aqueous samples can be analyzed easily by UV; this is not always possible with IR because water absorbs heavily in much of the IR region, and also because the lowest-cost materials generally used for sample-cell windows in IR instruments are water-soluble. UV generally is quantitatively superior to IR in the determination of *complex organic structures*, especially aromatic and heterocyclic compounds and those with conjugated double bonds.

Absorbing compounds fall into classes, the members of which have in common a specific configuration of atoms—called a chromophore—and similar absorption patterns. This characteristic provides a rapid means of determining structural features of a molecule.

Types of Spectrophotometers

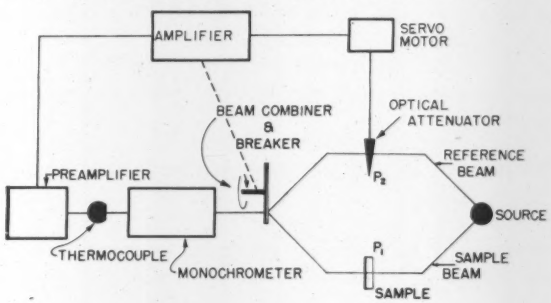
The basic types include single-beam, double-beam, prism, fore-prism grating and, recently, filter-grating types.

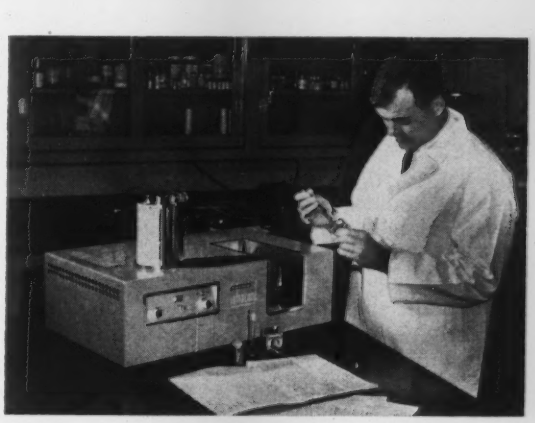
The single-beam type (Fig. 4) features simplicity and flexibility for unusual uses and experimentation.

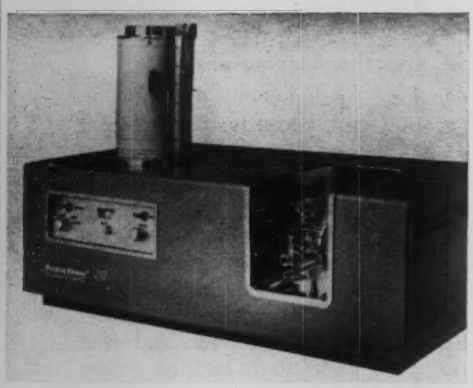
The double-beam type (Fig. 5) presents data free of atmospheric absorption, improves instrument reproducibility and permits direct differential-absorption measurements. Its simplicity and rugged construction mean that it can be operated by anyone and used in the chemical laboratory itself. The optics of a double-beam infrared spectrophotometer are shown in Fig. 6.

Either prisms or diffraction gratings can be used to separate the energy into its spectral components. Although gratings provide higher resolution, their use was limited until recently because they could not handle a complete spectrum without overlap of diffraction or-

FIG. 5. BLOCK DIAGRAM (of Perkin-Elmer Models 137 and 237 Infrared Spectrophotometer) illustrates dual radiation paths, P_1 and P_2, passed alternately to monochromator by rotating beam-combiner sector mirror.







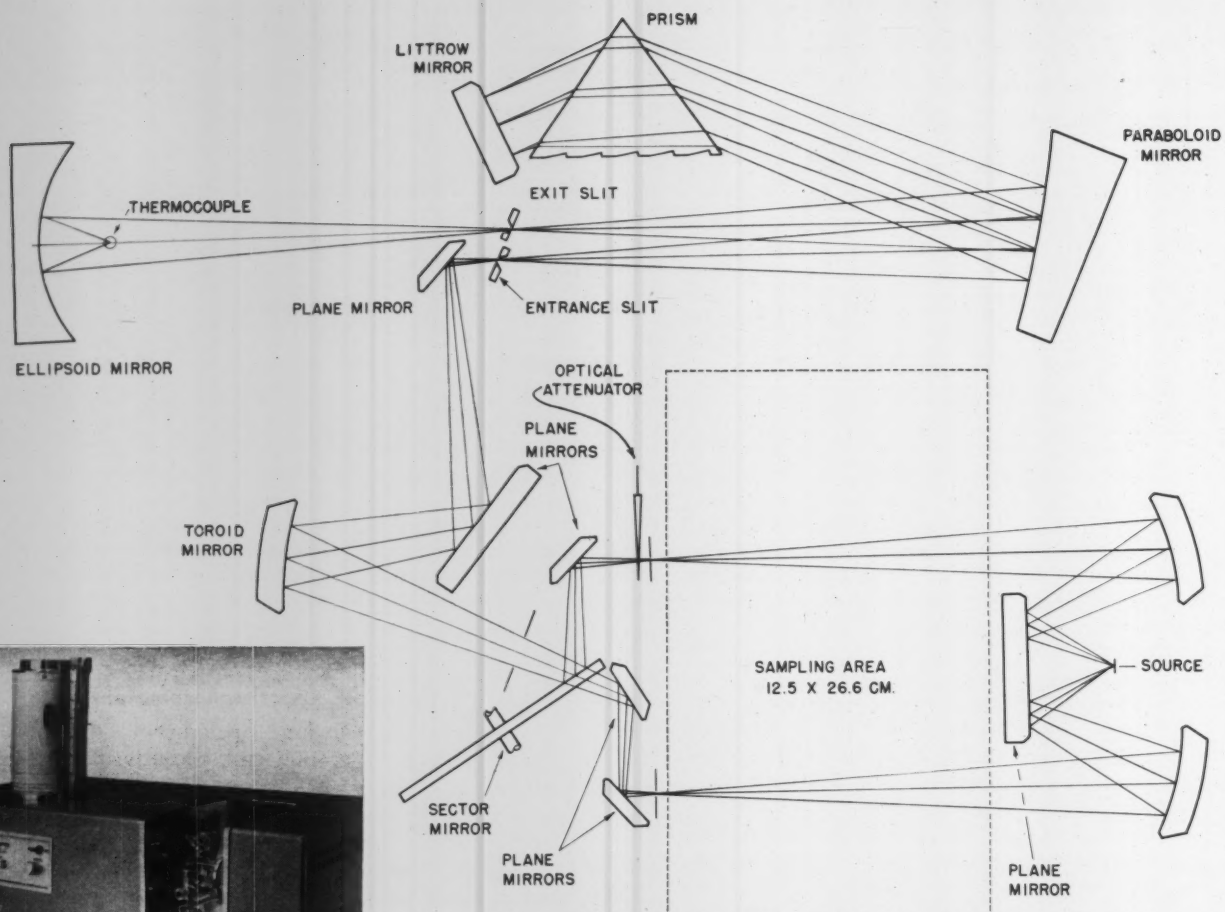


FIG. 6. OPTICAL ARRANGEMENT of Double Beam Infrared Prism Spectrophotometer (Perkin-Elmer Model 137). Sector mirror alternately reflects radiation of reference beam or allows transmission of radiation from sample beam, producing a "flicker" when beams are not equal in energy.

ders; thus fore-prisms had to be employed to separate the orders of radiation, with considerable instrumental complications. With the advent of readily available replica gratings, and the development of special infrared interference filters for the separation of orders without the use of a fore-prism monochromator, the feasibility of making moderate-cost commercially available grating instruments was realized (Fig. 7).

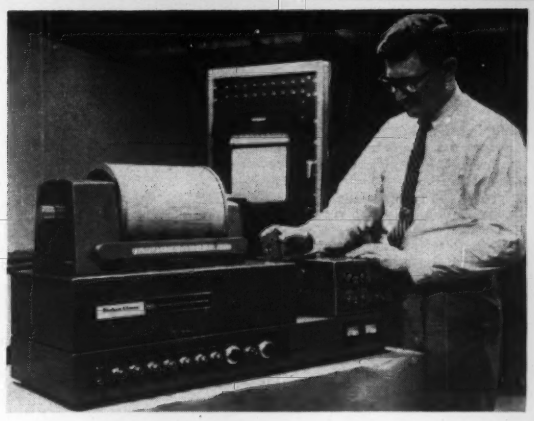
The high dispersion of the grating means that good resolving power can be achieved even when using simple slits and spherical mirrors. By using the high-quality optics usual in the best standard prism instruments, and employing a number of gratings and a variety of filtering methods, it is possible to cover the range from 2.5 μ to 180 μ with a resolution of the order of 1 cm^{-1} throughout (Fig. 7).

One problem involved in the design of this type of instrumentation is that the grating cannot readily be used in higher orders. Apart from requiring a filter with a long-wavelength cutoff to eliminate the lower orders, the short-wavelength cutoff filters are not sufficiently sharp to eliminate the higher orders while transmitting a reasonable fraction of the required one; this limits the range of a single grating.

Another design problem is in the spectral impurity, especially for wavelengths beyond 4 μ. In this region there will be much more radiation in the second and higher orders than the first, so that the filter efficiency in differentiating the orders might ordinarily be insufficient.

These two problems are solved by the use of more than one grating, each in its first order only, which is the most efficient order of the grating. Elimination of only the higher orders then can be done efficiently with special long-wavelength pass filters of a highly efficient interference type. Automatic means of changing the gratings and filters at the appropriate wavelengths are provided in the more popular instruments. The higher resolution of such instruments is obtained at somewhat greater cost, and perhaps somewhat less aesthetic spectra, relative to the common prism instruments.

The older, fore-prism grating type instrument (Fig. 8) also has design problems. Gratings used in higher orders diffract energy efficiently only in successively narrowing spectral regions, and require use of several orders to cover an adequate spectral range for the usual instrument. This complicates the scanning



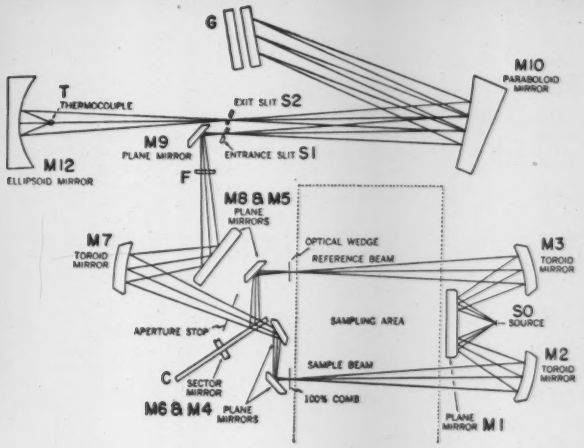


FIG. 7. OPTICAL SCHEMATIC (Perkin-Elmer Models 137-G and 237) shows dual back-to-back diffraction gratings (G) replacing salt prism of Fig. 6.

and recording mechanisms. The fore-prism monochromator, of necessity, adds much path length and several additional reflecting surfaces, both of which reduce the always all-too-little radiant energy throughput of the instrument, especially in regions of atmospheric absorption due to carbon dioxide and water. The long-wavelength energy absorption of practical prism materials also restricts the scanning range.

Realizing the need for a versatile high-resolution spectrophotometer with spectral slit widths of the order of 1 cm^{-1}, the grating arrangement has been introduced successfully in several commercially available spectrophotometers. These instruments, apart from a grating and order-sorter replacing a prism, are essentially similar generally to the prism instruments from which they have been developed.

As far as commercially available high resolution is concerned, the grating instrument now has been developed to a high state.

Comparison of IR Technique with Other Methods

The infrared spectrum, being rich in absorption bands, can provide much experimental data to the analyst or physicist studying molecular structure. The most useful modern physical techniques for *structure determination* are x-ray and electron diffraction, spectroscopy, and nuclear magnetic resonance. The application of x-ray and electron diffraction to analytical applications is limited. Visible and ultraviolet spectroscopy finds its usefulness limited when applied to the more complex molecules. The field of application of infrared spectroscopy is extensive, well known, and used in literally thousands of analytical areas, organic and inorganic, in agriculture, in air pollution, in coal research, in cosmetic research, in monitoring dairy products and narcotics, in studying emulsions, in silicone chemistry, etc., etc.

FIG. 8. FORE-PRISM grating spectrometer utilizes two Littrow-type monochromators in tandem between source-sample unit and energy detection system. First monochromator uses salt prism, while second uses appropriate diffraction grating to provide high spectral purity beam of very narrow spectral interval.

Units

Units designating position in the infrared region are either *wavelength in microns* or *wave numbers in* cm^{-1}. One should be able to use both units. The relationship is:

$$\text{Wave numbers} = \frac{10^4}{\text{Wavelength in microns}}$$

Table 1 lists the wavelength units used commonly in absorption spectroscopy.

Table 1—Wavelength Units Used in Spectroscopy

1 μ (micron) = 10^{-4} cm = 10^{-3} mm
1 mμ (millimicron) = 10^{-7} cm = 10^{-6} mm
1 A (angstrom) = 10^{-8} cm = 10^{-7} mm
1 μ = 10,000 A = 1000 mμ

Throughout the electromagnetic spectrum, the fundamental relationship is:

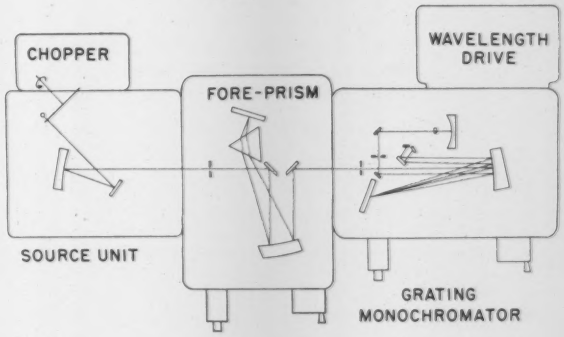
$$\lambda\nu = c$$

where λ is the wavelength of the radiation, ν is the frequency of vibration and c is the velocity of light (2.998×10^{10} cm/sec). This equation can be used to obtain the frequency of vibration of a wave of wavelength 2.998 microns as follows:

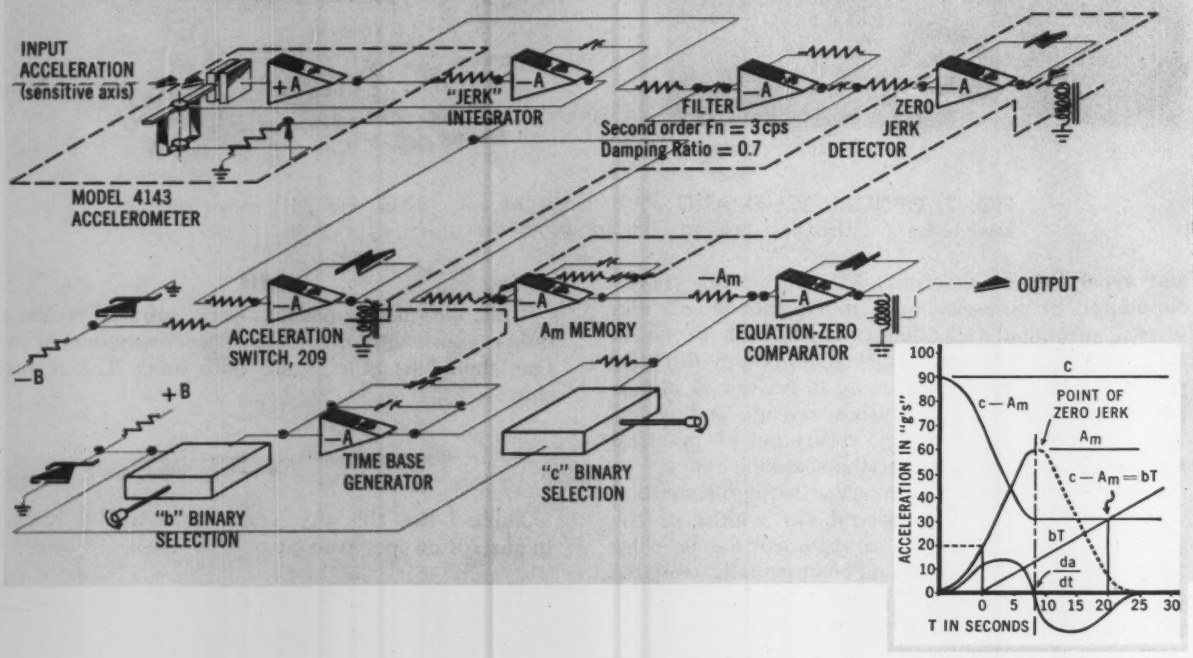
$$\nu = \frac{2.998 \times 10^{10}}{2.998 \times 10^{-4}} = 1 \times 10^{14} \text{ cps}$$

The wave number of this wave is:

$$\bar{\nu} = \frac{10^4}{2.998} = 3335.6 \text{ cm}^{-1}$$



Functional Diagram of Donner Accelerometer Timer Switch. Basically an airborne computer designed to solve a specific equation, this Donner device consists of a force balance accelerometer, whose output feeds to a jerkmeter for determination of peak acceleration (Jerk (da/dt) is the first derivative of acceleration). From the jerkmeter the signal passes through a filter and to a zero jerk detector which closes a switch at the peak acceleration. Other units in the computer are a peak acceleration memory, a 20 g acceleration switch which starts a time base generator and prevents the zero jerk detector from operating before a correct solution is possible, "b" and "c" selection binary units allow 64 values of "b" and "c" to be selected within the operating range, and an equation zero comparator which algebraically sums the output of the maximum acceleration memory circuit, time base multiplied by "b" and "c" circuit to close the relay output when $bT = c - A_m$. The curve below illustrates the equation and the fact that peak acceleration occurs at zero jerk.



How to Solve a Flight Equation

New Donner Airborne Analog Computer solves equation $bT=c-A_m$

where b = predetermined constant, T = time in seconds, c = predetermined constant, and A_m = peak acceleration achieved.

Causing a missile event to occur at just the right time and place in space is one of the critical problems faced by the control engineer. The programming device must be light, accurate, strong and, above all, reliable in severe environments.

When Donner engineers were confronted with this problem, they came up with a fixed purpose airborne analog computer known more specifically as an acceleration summing switch. The summing switch is a "thinking" device which responds to a particular environmental stimulus. Thinking for the vehicle, the switch measures time, multiplies it by a preset constant, equates the product to the memorized peak acceleration subtracted from a constant and when the sum reaches a predetermined value, actuates a relay. Such a point occurs during decreasing acceleration and is dependent on the magnitude of peak acceleration.

In solving this problem, Donner engineers combined their experience with computer techniques and servo force balance accelerometers. The device illustrated is all solid state.

Acceleration Summing Switch. This remarkable small computer is approximately 4" high and 2½" across. The two knobs on the top are used to set in "b" and "c" constants of the equation.

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COMPLETE TECHNICAL INFORMATION AVAILABLE
If you would like more information about this interesting application of computer and transducer techniques, our Mr. Stephen P. Cuff has prepared a technical discussion which he will be happy to send along. Please write Mr. Cuff at Donner Scientific.

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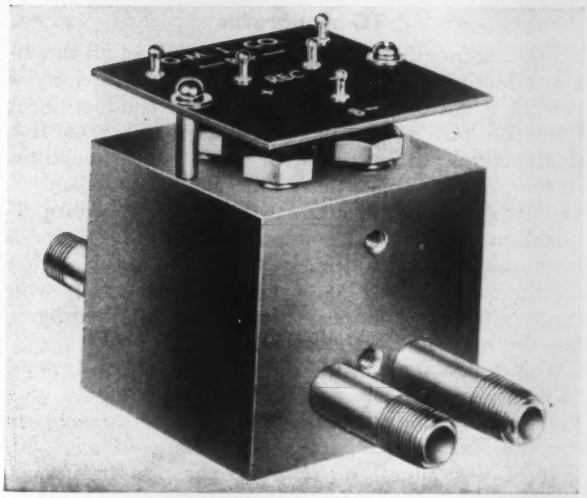

FIG. 1. THERMAL-CONDUCTIVITY cell unit.

JAMES L. McFADDEN
Gow-Mac Instrument Company

GAS ANALYSIS BY THERMAL CONDUCTIVITY

QUANTITATIVE DETERMINATION of the percentages of various constituents contained in a gas mixture is accomplished usually by performing a chemical analysis. The classical (Orsat) procedure necessary to determine the percentage of any one constituent consists of (1) metering a definite volume of the mixture into a gas analysis buret, (2) bringing the gas into contact with a reagent, which will react chemically with the particular constituent of the mixture being determined, and (3) measuring the change in volume after removing this constituent. This procedure is repeated with different reagents for removal of each of the other constituents of the mixture until the composition of the mixture is entirely known.

Ordinary gas analysis of this type is slow and tedious. Aside from the possible errors (gas leaks in the apparatus and incomplete reaction between the gaseous constituents and the absorbing reagents), the chief disadvantage of the chemical analysis method (Orsat) is that it is discontinuous; for example, it is not possible to control certain processes accurately and efficiently with discontinuous or intermittent chemical analysis.

It is possible to obtain a continuous indication of the composition of a mixture of gases, or of gases and vapors, by measuring the magnitude of some physical property which varies with the percentages of the constituents in the mixture. For example, hydrogen is widely different from oxygen in thermal conductivity, density, refractive index, viscosity, and specific heat. A number of methods of determining each of these properties can be used for analysis.

Use of *thermal conductivity* is accurate, simple, and fast. Many gases possess thermal conductivities of sufficient differences in magnitude to produce a measurable difference in thermal conductivity for a small change in the composition (% volume) of a mixture of these gases. This is the principle of thermal-conductivity gas analysis, which has been known to physicists and analytical chemists for more than 100 years. Most two-component and multi-component mixtures will exhibit a change in thermal conductivity sufficiently linear with changes in composition to enable simple calibration of indicator scales. Calibration, and operation, must follow Boyle's law—that is, both sample and reference gases should pass through the apparatus at constant pressure and flow rates, as well as at constant temperature.

Definition of Thermal Conductivity

Thermal conductivity is defined in terms of the heat conducted through the gas. It is defined as the quantity of heat conducted through the gas, in unit time, between two surfaces of unit area in the gas, when the surfaces are unit distance apart and the temperature differences of the surfaces is one degree Centigrade. This definition sounds complicated, but the apparatus used for measuring thermal conductivity is simple and inexpensive.

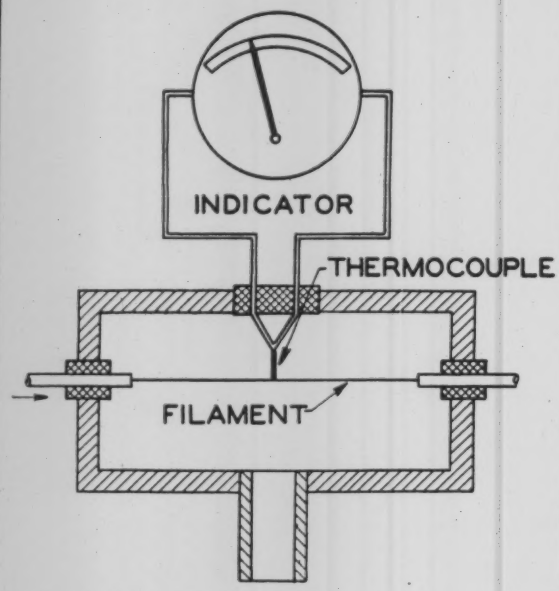

FIG. 2. PRINCIPLE of one cell. Temperature of filament is measured by thermocouple.

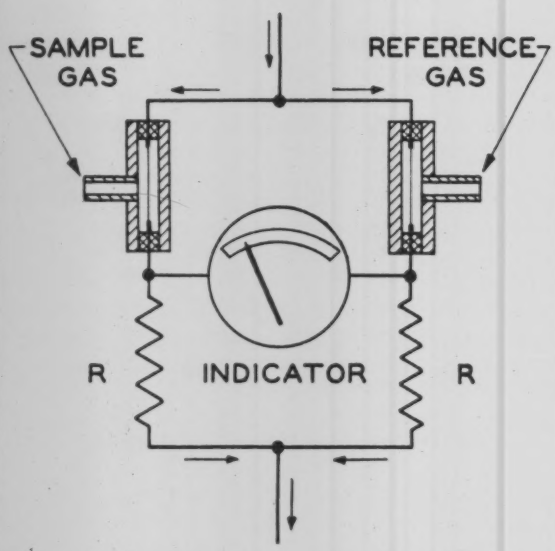

FIG. 3. STABILITY and accuracy is achieved by measuring changes in conductivity of sample gas as compared against that of reference gas.

TC Apparatus

Fig. 2 shows the fundamental principle of all thermal-conductivity apparatus. A fine wire heated by a current is surrounded by a gas which conducts heat from the wire to the walls of the chamber. A fine thermocouple in contact with the hot wire measures its temperature above that of the wall of the chamber. The temperature difference will be inversely proportional to the thermal conductivity of the gas for a given power input to the hot wire. A good rule is that the thermal conductivity of a gas varies inversely with its density; for example, the lightest gas, hydrogen, has the highest thermal conductivity.

The design shown in Fig. 2 is not practical. Instead of measuring the absolute thermal conductivity of a gas, as is done in Fig. 2, it is much simpler to *compare* the thermal conductivity of the unknown gas with that of a standard or reference gas, as in Fig. 3. (Thermal conductivities of unknown gases are measured relative to air, to hydrogen, or to any other suitable standard.) This eliminates several errors, particularly those due to changes in temperature of the apparatus. As the thermal conductivity of the reference gas is known, it is a simple matter to calculate the absolute conductivity of the unknown gas from (1) the measured relative conductivity and (2) the known absolute conductivity of the reference gas.

Fig. 3 shows two similar current-heated filaments in two similar cells, and two similar inert resistances. The four elements are connected to form a Wheatstone bridge. If the reference cell contains air and the sample cell contains a gas having a different thermal-conductivity, the two hot wires will not be at the same temperature, and they will not have the same resistance. The bridge then will become unbalanced to an extent depending on the difference in conductivity. The extent to which the bridge becomes unbalanced will depend also on the percent composition of the sample, and the scale on the indicator can be calibrated in terms of percent composition.

The Wheatstone bridge is now universally used in thermal-conductivity apparatus. Use of four active filaments (Fig. 4) instead of the two shown in Fig. 3, increases the sensitivity to a given change in composition. These filaments are matched for temperature coefficient of resistance, and are usually of tungsten or platinum.

Thermistors as well as metallic filaments can be installed as legs of the Wheatstone bridge in a thermal-conductivity cell. (Glass bead thermistors on platinum support wires are used widely in chromatography detectors, although their negative temperature-coefficient-of-resistance results in a decreasing signal as the cell-block temperature increases.)

It is not always necessary to know the absolute or relative thermal conductivity of the unknown. Often the only question that is really important is how much *change* on the indicator can be produced by a given *change* in the composition of the mixture, which can be established empirically.

Applications

The quantity of heat conducted by a gas varies with the nature of the gas, extending from poorly con-

ducting vapors (having only one-fifth the conductivity of air) to hydrogen (having seven times the conductivity of air). Gas and vapors of any conductivity between these two extremes can be analyzed accurately by proper selection of the reference gas. Values of thermal conductivity have been determined for a large number of gases and vapors. Some are shown in Table 1. In this table, R_o is ratio of conductivity to air at 0°C.

Table 1—Thermal Conductivity Measurement Factors of Various Gases and Vapors.

Molecular Weight	Boiling Point °C.	GAS	Relative Deflection for 1% Gas in Air	R_0	Approx. Bridge output in Millivolts, No Load 4 Kovar	4-W	2-GBT
58.08	56.5	Acetone	—0.18	.406	—0.8	— 3.4	—12.0
17.03	— 33.35	Ammonia	0.079	.897	0.6	2.5	8.8
39.994	—185.7	Argon	—0.13	.684	—0.5	— 2	— 7.0
44.01	— 78.5	Carbon Dioxide	—0.143	.605	—0.75	— 3	—10.5
28.01	—190.0	Carbon Monoxide	—0.014	.960	—0.1	— 0.4	— 1.4
70.91	— 33.7	Chlorine	—0.356	.323	—2.5	—10	—35
52.03	— 51.6	Freon 12		.344			
4.003	—268.9	Helium	0.64	5.97	4.3	17.2	60.
2.016	—252.8	Hydrogen	1.	7.15	7	28	90.
16.04	—161.5	Methane	0.12	1.25	0.8	3.5	10.5
94.95	3.56	Methyl Bromide		.257			
28.02	—195.8	Nitrogen	—0.001	.996	0.06	— 0.25	0.9
32.	—183.1	Oxygen	0.006	1.013	0.1	0.45	2.6
64.06	— 10.0	Sulphur Dioxide	—0.418	.350	—3.12	—12.5	—44.
18.02	100	Water Vapor	0.068	.775	100°C		
1	2	3	4	5	6	7	8

Fig. 5 shows instrument deflections (arbitrary divisions) for some common binary mixtures. Curve 1 is for H_2 in air; 2 is for SO_2 in air; 3 is for argon in helium; 4 is for argon in hydrogen; etc. The reference gas used should be the major constituent in the mixture. For example, if one wishes an operating range of 90%-100% H_2 in N_2, he should use H_2 as his reference gas. Conversely, N_2 would be used as the reference gas if the operating region is 0-10% H_2 in N_2.

Where ammonia, freon, helium, methyl bromide, natural gas, or sulphur dioxide, etc., is to be measured in air, air is used as the reference gas. Air reference is also used for cylinder identification. In products of combustion, nitrogen is usually the reference for carbon dioxide, hydrocarbons, or hydrogen; reducing or normal furnace atmospheres are identified readily. Comparative purity of industrial gases is observed with a high-purity reference gas of certified analysis.

Gas-purity analyzers and gas blenders for process work have a thermostatted cabinet for the transducer, a DC power supply with constant-current regulation for filament heating, pressure-flow regulation of sample and/or reference gas-streams, and recorder readout.

Gas chromatographs resemble gas-purity analyzers, and most of them have thermal-conductivity detectors. These special transducers have a faster response than the on-stream type, and observe the transient contaminants of the helium carrier stream at temperatures as high as 450°C.

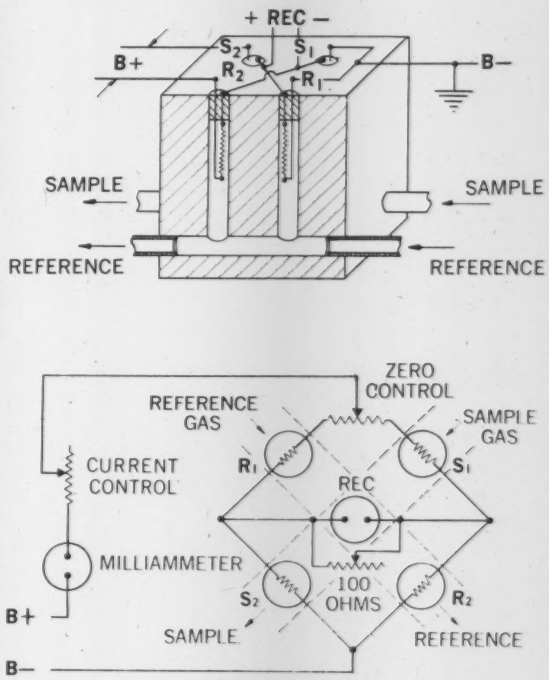

FIG. 4. FOUR-FILAMENT bridge increases sensitivity.

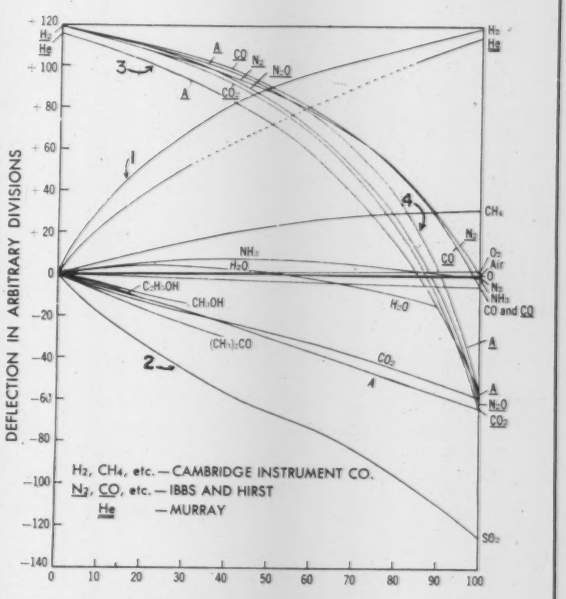

FIG. 5. INSTRUMENT DEFLECTION versus composition of gas-air mixtures (per cent gas in air) for various gases using a reference cell with air, hydrogen or helium.

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CIRCLE 85 ON READER-SERVICE CARD

Applications of Process Stream Analyzers

DAVID J. FRAADE
Consolidated Electrodynamics Corp.

Analytical instruments of all types are finding increasing use as continuous monitors and controllers of process streams. This table reports some typical applications of process stream analyzers, including plant and service.

TABLE 1—TECHNIQUES USED

Infrared

Acetylene in oxygen, methane, ethylene, or carbon dioxide
Butene-2 in n-Butane
Carbon Dioxide in air, acetylene, N_2 H_2, or CO
Carbon Monoxide in hydrogen, nitrogen
Water in air
Water (liquid) in liquid SO_2

Ultraviolet

Butadiene in butanes and butylenes
Divinyl Acetylene in acrylonitrile
Hydrogen Sulfide in natural gas

Refractometer

Butadiene in styrene
Cyclohexane in n-Hexane, methyl cyclopentane
Iso-butane in n-Butane (liquid)
Ortho and Meta xylene in para-xylene
Styrene in ethyl benzene
Xylene Isomers in isomers

Mass Spectrometer

Ethylene Oxide in methane, ethane, propane
Hydrocarbon in H_2S, CO_2, air
Nitrogen in argon
Oxygen in ethylene, argon
O_2, N_2, CO, or H_2O in hydrogen

Electroconductivity

Carbon Dioxide in nitrogen
Carbon Tetrachloride in air
Methylene Chloride (solvent recovery)
Nitric Oxide in air
Oxygen in water

Thermal Conductivity

Chlorine in air
Helium in oxygen, nitrogen
Hydrogen in oxygen, nitrogen, or inert gas
Oxygen in argon, hydrogen

Chromatography

Ethylene in C_1—C_6 (0-5%), H_2, C_1—C_4 (0-20%)
Ethylene in C_1, C_2, CO_2 (50-100%)
Iso-butane in C_3, nC_4, iC_5

Titrilog

Hydrogen Sulfide in H_2—N_2
Hydrogen Sulfide in natural gas
Mercaptan in natural gas

Chemical Colorimetric

Hydrogen Sulfide in hydrocarbon

Paramagnetic

Oxygen in nitrogen, stack gases, CO_2 CO, N_2

Thermal Convection

Oxygen in nitrogen

Moisture Monitor

Water in kerosene
Water in LPG

Thermoelectric

Water in air

TABLE 2—APPLICATIONS

COMPONENT	CONCENTRATION	OTHER MAJOR CONSTITUENTS	PLANT	SERVICE	ANALYZER
Acetylene	0.8 ppm	Oxygen	Air Separation	Liquid Air Vaporizer	Infrared
Acetylene	0-20%	Methane, Ethylene	Acetylene	Partial Oxidation	Infrared
Acetylene	0.3%	Carbon Dioxide	Acetylene	Absorber OFF Gas	Infrared
Butadiene	0-10%	Butanes and Butylenes	Butadiene	Purification	Ultraviolet
Butadiene	3/1 Ratio	Styrene	Blending	Syn. Rubber Feed	Refractometer
Butene-2	0-70%	n-Butane	Butadiene Plant	Furfural Extractive Distillation	Infrared
Carbon Dioxide	5 ppm	Air	Air Separation	Treated Air	Infrared
Carbon Dioxide	0.5%	Acetylene	Acetylene	Acetylene Product	Infrared
Carbon Dioxide	50 ppm	Nitrogen	Air Separation	Product	Electroconductivity
Carbon Dioxide	0-1%	N_2, H_2, CO	NH_3	Synthesis Plant	Infrared
Carbon Monoxide	10 ppm	N_2, H_2	Ammonia	Nitrogen Wash Tower OH and Synthesis Gas	Infrared
Carbon Tetrachloride	1000 ppm	Air	Cleaning Plant	Personal Safety	Electroconductivity
Chlorine	10 ppm	Air	Storage	Air Pollution Cont.	Thermal Conductivity
Cyclohexane	60%	n-Hexane	Petro-Chem	Distillation Column	Refractometer
Cyclohexane	0-5%	Methyl cyclo-pentane	Cyclohexane Recovery	Demethyl cyclo-pentanizer	Refractometer
Divinyl Acetylene	0.5 ppm	Acrylonitrile	Acrylonitrile	Product	Ultraviolet Spectrophotometer
Ethylene	0-5%	C_1—C_6	HF Alkylation		Chromatography
Ethylene	0-20%	H_2, C_1—C_4	HF Alkylation		Chromatography
Ethylene	50-100%	C_1, C_2, CO_2	Polyethylene Plant		Chromatography
Ethylene	75-100%	C_1, C_2, CO_2	Polyethylene Plant		Chromatography
Ethylene Oxide	0-50%	C_1, C_2, C_3	Natural Gas to Ethylene Oxide		Mass Spectrometer
Helium	+99.9%	Oxygen and Nitrogen	Gas Separation	Product	Thermal Conductivity
Hydrogen Sulfide	0-10 ppm	H_2—N_2	Ammonia Synthesis Plant		Titrilog
Hydrocarbon	0-10%	H_2S, CO_2	Sulfur Recovery		Mass Spectrometer
Hydrocarbon	0-1%	Air	Drilling Mud Logging		Mass Spectrometer
Hydrogen	+99%	Oxygen and Nitrogen	Air Separation	Product	Thermal Conductivity

Note: C_1 is methane; C_2 is ethane; C_3 is propane; C_4 is butane; C_5 is pentane; C_6 is hexane; etc.

TABLE 2—CONTINUED

COMPONENT	CONCENTRATION	OTHER MAJOR CONSTITUENTS	PLANT	SERVICE	ANALYZER
Hydrogen	200 ppm	Inert Gas			Thermal Conductivity
Hydrogen Sulfide	10 ppm	Hydrocarbon	Refinery	Sour Water Stripper	Chemical Colorimetric
Hydrogen Sulfide	0-1 gr/ 100 CF	Natural Gas	Natural Gas Purification		Titrilog
Hydrogen Sulfide	0-2%	Propane-Propylene	LPG Purification		Ultraviolet
Iso-butane	0-100%	C_3, nC_4, iC_5	HF Alkylation		Chromatography
Iso-butane	10%	n-Butane (Liquid)	Alkylation	Distillation Column	Refractometer
Mercaptan	0-2 lb/ MM CF	Natural Gas	Odorization of Natural Gas		Titrilog
Methylene Chloride	1%		Solvent Recovery	Recovery Bed Effluent	Electroconductivity
Nitric Oxide	100 ppm	Air	Storage	Air Pollution Control	Electroconductivity
Nitrogen	0-10 ppm	Argon	Argon		Mass Spectrometer
Ortho and Meta xylene	0-5%	para-xylene	High Purity Para-xylene Process		Refractometer
Oxygen	1%	Nitrogen	Air Separation	Purified Nitrogen	Paramagnetic
Oxygen	3%	Stack Gases	Nitric Acid Plant	Stack Gas	Paramagnetic
Oxygen	1%	CO_2, CO, N_2	Fluid Cat. Cracker	Regeneration Flue Gas	Paramagnetic
Oxygen	1 ppm	Water	Boiler	Boiler Feed Water	Electroconductivity
Oxygen	0-10 ppm	Nitrogen	Air Separation	Treated Air	Thermal Convection
Oxygen	6-98%	Argon or Hydrogen	Air Separation	Product	Thermal Conductivity
Oxygen	0-10 ppm	Ethylene	Polyethylene		Mass Spectrometer
Oxygen	0-10 ppm	Argon	Argon		Mass Spectrometer
0_2, N_2, CO, H_2O	0-5%	H_2	Vacuum Metal Refining		Mass Spectrometer
Styrene	Range	Ethyl Benzene			Refractometer
Water	0-100 ppm	Kerosene	Jet Fuel Processing	End Product Purification	Moisture Monitor
Water	50 ppm	Air	Air Separation	Treated Air	Infrared and Thermoelectric
Water	0-20 ppm	LPG	Refinery, Natl. Gasoline	General Processing	Moisture Monitor
Water (Liquid)	0-0.3% by wt.	Liquid SO_2	Aromatic Extraction		Infrared
Xylene Isomers	0-5%	Isomers	Para-Xylene	Product	Refractometer

Note: C_1 is methane; C_2 is ethane; C_3 is propane; C_4 is butane; C_5 is pentane; C_6 is hexane; etc.

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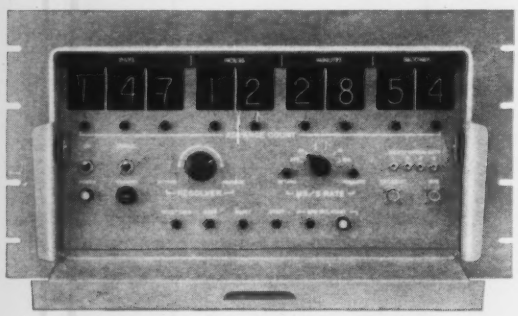

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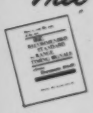

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2

CIRCLE 86 ON READER-SERVICE CARD

FIG. 1. BRYANT'S new Series 4000 Disc Files.

DISC FILE MEMORIES

HAROLD J. McLAUGHLIN
Bryant Computer Products

How do you get data into and out of a disc-file-type memory? This article describes a variety of applications of the disc file type memories to random-access data processing. Serial and parallel operation, as well as discrete clocking, selective alteration and interlacing, are included. Frequency and capacity can be varied over a wide range. This is number 9 in a series on data storage.

DISC FILES are becoming increasingly popular for data storage where access to large amounts of data is required in milliseconds.

The 4000 Series Disc Files (Fig. 1) are memories comprising 39″-diameter magnetic discs rotating on a common shaft at 900-1200 rpm. The maximum-capacity equipment (Model 4240) has 24 discs (48 recording surfaces).

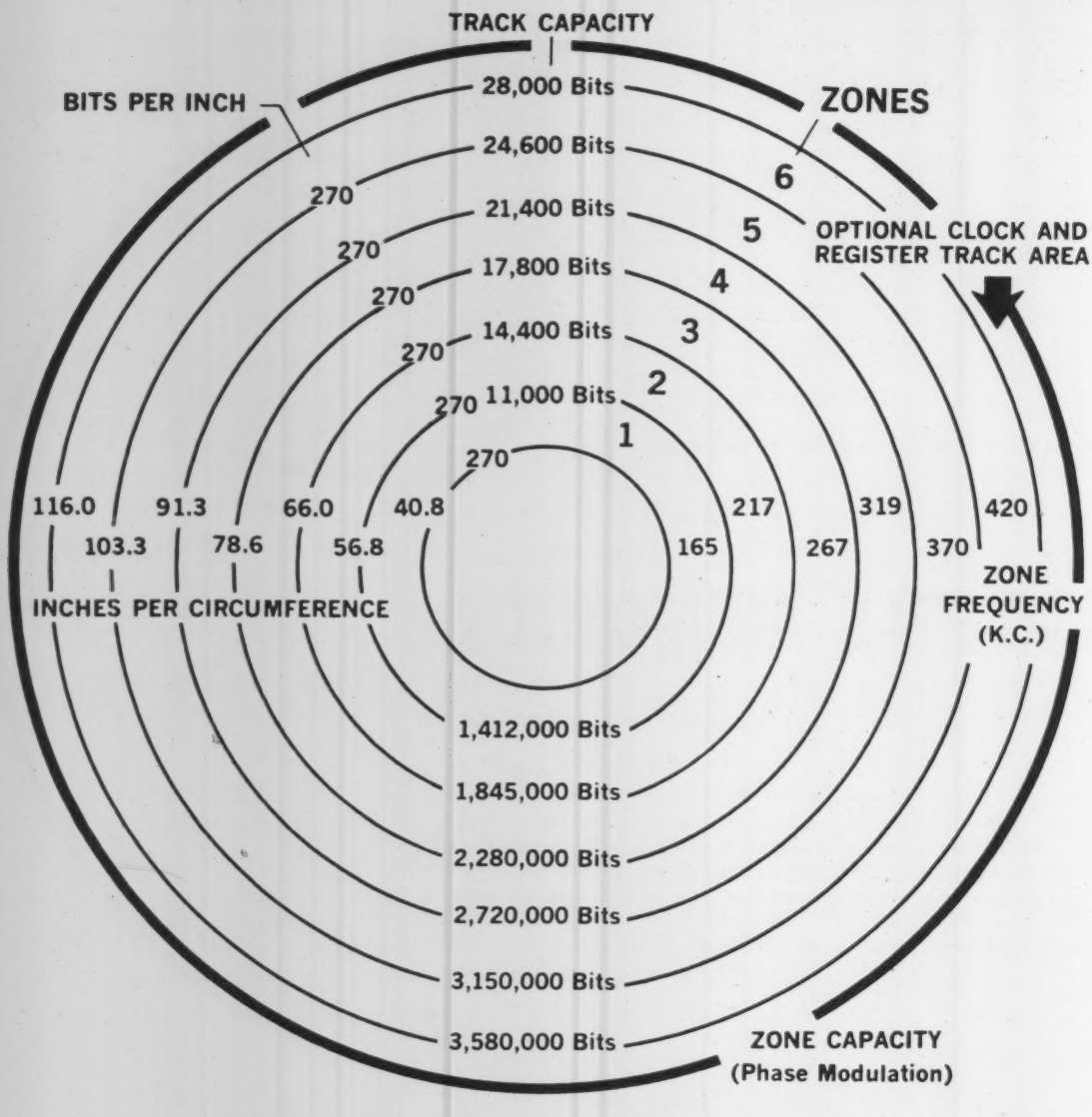
Each surface is serviced by six magnetic heads, each of which can assume any one of 128 positions, giving a total of 768 concentric recording tracks.

A hydraulic positioning mechanism moves all 288 heads (for the 48 surfaces) simultaneously to a selected track within 100 milliseconds. This 100-millisecond positioning operation provides access to 288 tracks of data, or approximately 6,000,000 bits. Switching between the 288 heads is accomplished electronically in 10-50 microseconds.

The length of each of the 768 concentric tracks on a disc surface depends on its radius. Maximum bit loading of the surface would dictate use of the maximum allowable bit density in every track. However, this would result in a separate capacity and frequency for each track. Therefore, some bit capacity is sacrificed to reduce the number of track capacities and frequencies to a reasonable minimum. This is accomplished by grouping the tracks in concentric zones, in each of which the innermost track uses the maximum allowable bit density (or a convenient lower density), and all other tracks have this same capacity and frequency. A maximum of six zones are used on each surface, one for each head.

A typical six-zone arrangement is shown in Fig. 2. Using a maximum bit density of 270 bits per inch and a disc speed of 900 rpm, this arrangement achieves the frequencies shown, and a total surface capacity in excess of 15,000,000 bits.

Another (and perhaps the most popular) disc arrangement is shown in Fig. 3. This arrangement has two zones per surface, each served by three heads. A maximum bit density of 275 bits per inch is used in the inner track in the inner zone, and a maximum of 285 bits per inch in the inner track of the outer zone. This produces an inner-zone track capacity of 11,200



MAXIMUM CAPACITY TRACK LAYOUT

FIG. 2. SIX HEADS are used to service each disc. Each zone, serviced by one head, has its own maximum bit density. Each track in zone 6 has 28,000-bit capacity, giving a zone capacity of 128 × 28,000, or 3,580,000 bits. Each zone has its own timing track (zone frequency).

bits per track. Outer-zone capacity is 22,400 bits per track—exactly double the capacity of the inner zone tracks.

In the outer-zone tracks, 2:1 interlacing is used to produce in each physical track two separately-addressable channels (made up of alternate bits in the track) having the same capacity as the inner-zone tracks. This results in a total of 1,152 separately-addressable tracks per disc surface, each having a capacity of 11,200 bits and a data frequency of 224 kc at 1200 rpm.

Many other track arrangements can be used to satisfy individual system requirements for track length, data frequency, capacity, etc.

Discrete Clocking

All data is recorded in *phase-modulation type** recording, and is discretely clocked—that is, each bit is recorded in a predetermined cell as defined by a prewritten timing track, under control of that timing track. In this manner each bit is precisely positioned and can be erased without affecting adjacent bits, simply by writing a new bit of opposite binary significance in the same cell (under control of the same timing track). This changing of a single bit in a track is known as *selective alteration*.

In addition to eliminating the need for blank spaces between blocks of data, selective alteration simplifies file updating because only changed items, rather than complete data blocks, need be recorded.

Timing Tracks

A timing or clock track, including a precisely recorded signal for each bit position, is supplied for every zone. A single timing-track on one disc serves like zones on all discs.

A timing diagram illustrating the relationships between the timing signals and the data being recorded and played back is shown in Fig. 4. The timing tracks (phase-modulation recorded) control writing of data by gating NRZ-type** information into the recording circuits.

Timing of played-back data is achieved by differentiated timing signals, suitably delayed as indicated in Fig. 4 to compensate for the inherent delays in the playback process. Electronic delays can be used, or separate read heads can be used to produce the read timing pulses. In the latter case the delay is achieved by adjusting the relative positions of the heads.

In addition to the timing tracks, an index track incorporating a single pulse is used to mark the zero (datum position) on each disc. Also, where the data tracks are divided into a number of angular sectors for addressing purposes, sector tracks can be included to mark the boundaries, or can include code words which identify the sectors.

Bit Interlacing

Each track operates at a fixed clock frequency. In order to accommodate binary data rates which are submultiples of this frequency, bit interlacing is used —that is, each track is divided into separately addressable channels, each including every second, third, or Nth bit of the physical track. Each channel, therefore, operates at the frequency of the input system, which is lower than that of the clock.

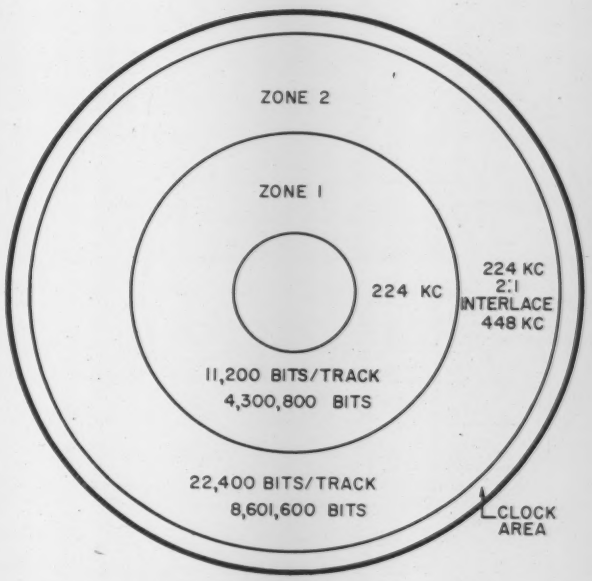


FIG. 3. TWO-ZONE LAYOUT wherein each track in outer zone has twice the bit capacity of the tracks in the inner zone. Both zones have 384 tracks, 3 heads (128 tracks each).

*In phase-modulation recording, DC of one polarity is applied to the head during the first half of a pulse period and, at the mid-point of the period, the polarity is reversed for the second half. The order in which the two polarities are applied to the head during each period determines the binary significance.

**NRZ (non-return-to-zero) data utilizes one DC level to represent binary one, and another to represent binary zero.

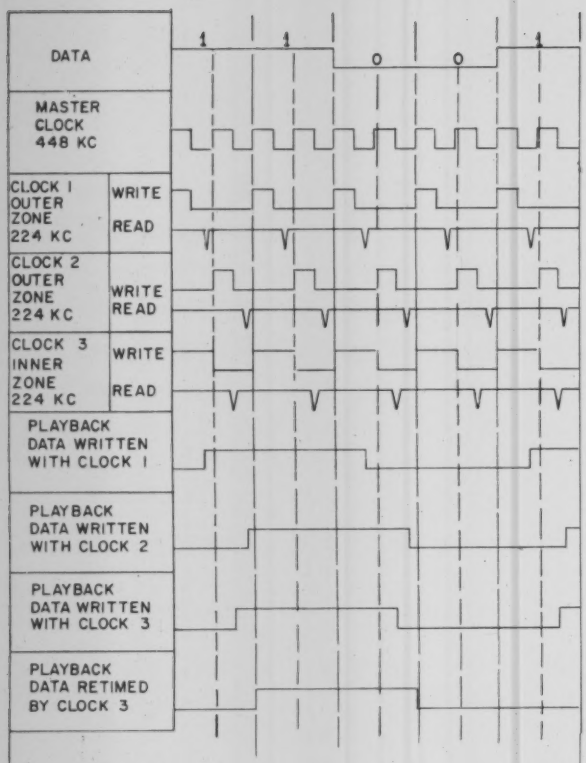


FIG. 4. INTERLACE TIMING diagram for data pattern 11001 as recorded in each interlaced channel (alternate bits of a 48 kc track) and in a non-interlaced, inner zone track (224 kc). Clocks 1 and 2, together, provide a 448-kc clock while clock 3 is at 224 kc. Clock 1 pulses control recording and reading during the first half of each 224-kc period and clock 2 during the second half. Clock 3 controls recording of broader signals across the entire 224-kc period.

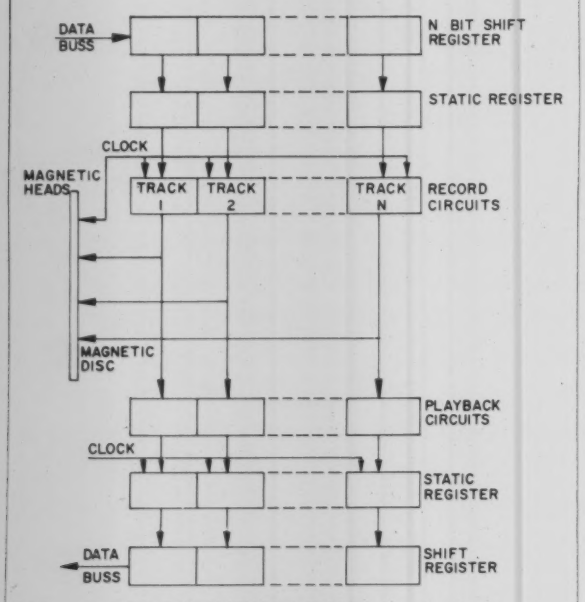


FIG. 5. TRACK INTERLACING block diagram.

Track Interlacing

Data rates which are multiples of the clock frequency are accommodated by using *track interlacing*. This technique uses several tracks, each of which records part of the data. For example, if the incoming data to be recorded has six times the clock frequency, six tracks are used, with one of the six bits being recorded in each track. In other words, N tracks are operated in parallel to record, simultaneously, N bits of a serial data train having a frequency N times that of each track.

Fig. 5 illustrates an input-output arrangement for track interlacing where the frequency of the data buss is N times that of the tracks in which the data is to be recorded. Data is fed into an N-stage shift register at the frequency of the buss. At the end of each Nth-bit period, the contents of the shift register are shifted in parallel to a static register which drives N record circuits in parallel (under control of clock or timing pulses from the disc file). Thus, in every Nth-bit period, N bits are recorded in parallel in N tracks.

Playback (PB) operations are the reverse—that is, the PB amplifiers for the N tracks set the N stages of a static register once every N bit periods. These settings are transferred into a shift register from which they shift onto the data buss at its frequency.

Serial Operation

Fig. 6 is a typical two-zone, single-frequency serial application. This 24-disc system utilizes 2:1 interlacing (Fig. 3) to provide a single track length of 11,200 bits, and a single data frequency of 224 kc throughout the file; 55,296 separately-addressable channels or tracks of 11,200-bit capacity are available. Each track is further divided into ten sectors, each capable of storing 160 seven-bit characters.

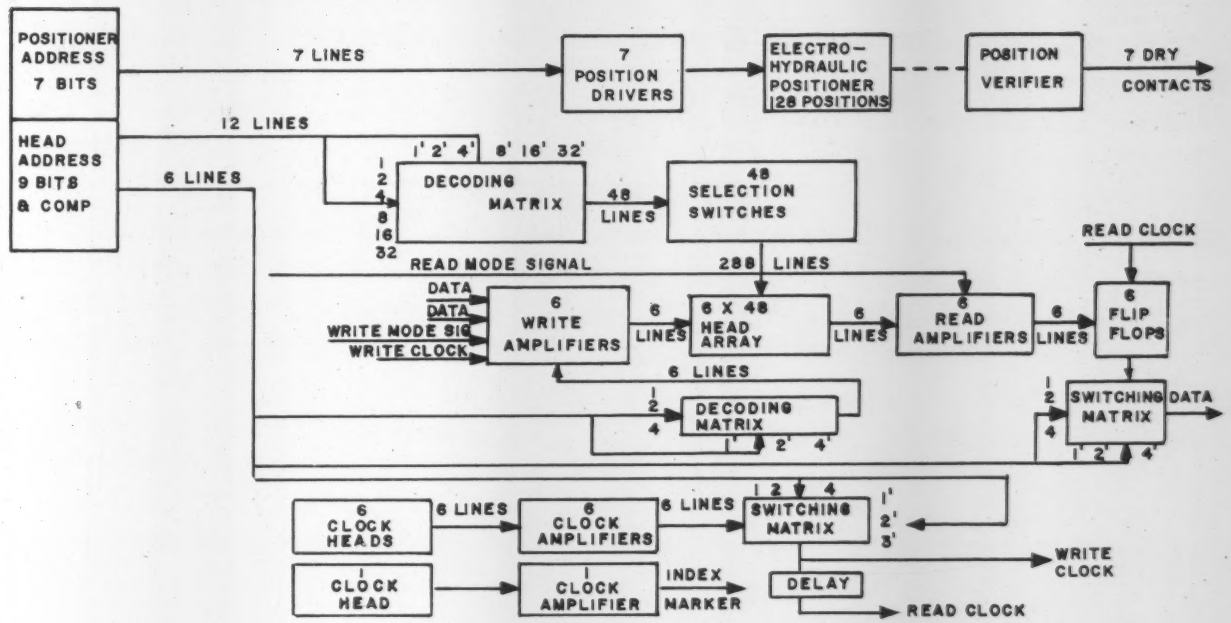


FIG. 6. SERIAL APPLICATION of a disc file. Seventeen bits are used to select proper channel. First seven bits of address direct all heads to proper track (one of 128); next six bits select proper disc; last 3 bits select proper head (one of six). Last bit helps select proper clock.

Addressing is accomplished by a 17-bit word as follows:

1. A seven-bit positioner address selects one of 128 positions for all heads.

2. Six bits of the address select the disc surface by selecting one of 48 groups of six heads. The heads are ordered across the file beginning with the innermost heads. Heads 1 through 48 are the innermost track, and heads 241-288 are the outermost track.

3. Three bits of the address select one of the six write or read circuits in cooperation with "read-mode" and "write-mode" signals. This completes selection of a single head for serial operation.

4. The 17th bit of the address, and one bit of the read-write-amplifier selection group, serve to select the appropriate clock, as illustrated in Fig. 4. Clocks 1 and 2 are used in the interlaced tracks, and clock 3 is used in all of the inner zone tracks. As indicated, clocks 1, 2, and 3 are generated electronically from a master clock.

In order to provide the proper phase relationship between the write and read clocks, a separate read head and gating is used to provide properly delayed read clocks 1 and 2. A third head and gating is used to produce the differently delayed read clock 3.

Data is presented to the file in NRZ form at 224 kc (Fig. 4) under control of timing pulses supplied by the file. This data is "anded" with the selected one of the three operating clocks for recording in the appropriate track. During playback operations the data is read back using the appropriate read clock.

This results in misalignment pulse periods because of the delayed timing of the read strobe pulses. In order to realign the data, it is strobed out of the playback circuit flip-flop into a second flip-flop under control of write clock 3 as shown in Fig. 4.

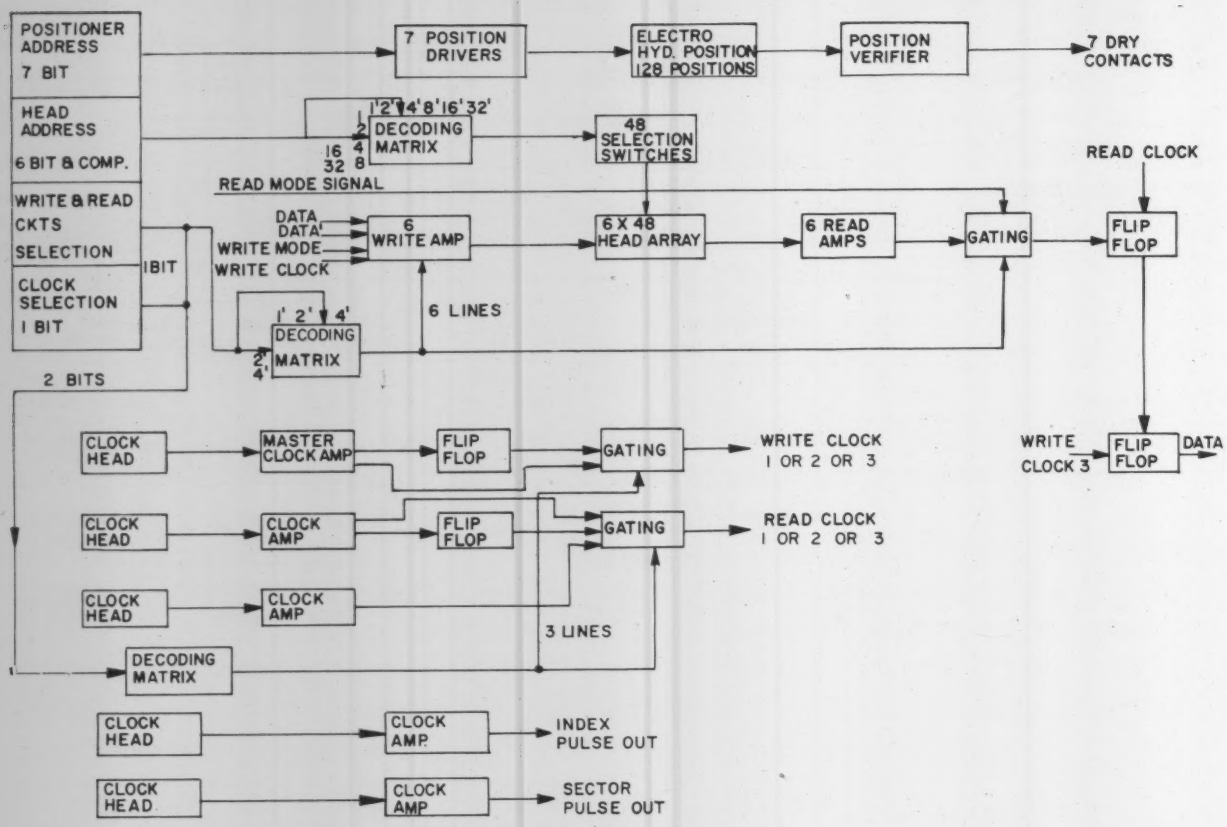


FIG. 7. PARALLEL OPERATION. A 7-bit character is written or read simultaneously. A 15-bit address word is used to select the channel. First 7 bits select 1 of 128 positions for all heads; next 5 bits select 1 of 30 groups of 7 heads; remaining 3 bits select clock track.

Parallel Operation

In parallel operation, N-bit characters are written and read in parallel; that is, all N bits are written or read simultaneously.

Parallel operation of the disc file is illustrated in Fig. 7. This typical seven-bit parallel system uses 35 recording surfaces on 18 discs for storage of 75,000,000, seven-bit characters. Six zones are used on each surface.

To record seven-bits simultaneously, seven heads (selected from the same zone) are used as a group. Thirty such groups of seven heads (five groups per zone) are provided. Any group of seven heads can record seven bits (one character) simultaneously.

Selection of seven tracks for simultaneous read or write operations is accomplished in three stages under control of a 15-bit address word:

1. A seven-bit positioner address selects one of 128 positions for all of the heads.
2. Five bits of the address select one of the 30 groups of seven heads.
3. The remaining three bits of the address are used to select the appropriate clock track.

The programmer and the computer interface designer must compensate for the variations in capacity and frequency from zone to zone, as in serial operation.

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Where it's important to maintain accurate liquid level control, it's risky to bank on a float or displacement type control when you can get one that's stable—never thrown off course by waves or surface turbulence—one that's designed simply and huskily built for year after year dependability.

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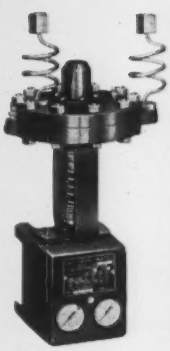

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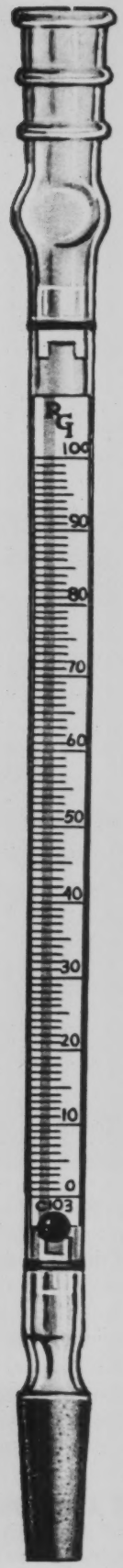

ROGER GILMONT
PAUL W. MAURER

A GENERALIZED EQUATION FOR

A simplified generalized correlation (flow equation) for a rotameter can be developed by considering the case of a spherical float in a plain, tapered tube, such as is commonly used in sphere sizes up to ½". A modified coefficient, C_R, is obtained by using an effective "terminal velocity" (obtained from Stokes' Law) rather than the velocity-head term usually found in the C_R coefficient.

Terminology

q = rate of flow (volumetric) through rotameter
D_t = diameter of rotameter tube
D_f = diameter of rotameter float
V = velocity of flowing fluid
V_t = terminal velocity = maximum velocity of an object falling through a fluid.
W_f = weight of float
ρ = density of flowing fluid
ρ_f = density of float
A = cross-section of flow orifice (annulus in rotameter)
g = acceleration due to gravity
ΔH = pressure drop across A in head of fluid flowing
$(\Delta H)(\rho)$ = pressure drop across A in psi
$R_{n\text{-}pipe}$ = Pipe Reynolds number
$= \rho VD/\mu$ (where D is diameter of pipe, ρ is density of flowing fluid, μ is absolute viscosity), dimensionless
$R_{n\text{-}annulus}$ = Annulus Reynolds number
$= \rho V (D_t - D_f)/\mu$, dimensionless
S-R_n = Stokes-modified Reynolds number, dimensionless
$= \dfrac{g (D_t - D_f)^2 \rho(\rho_f - \rho)}{18 \mu^2}$

THE BASIC EQUATION of flow for a rotameter can be expressed as:

$$q = C_R A\sqrt{2g\,\Delta H} \qquad (1)$$

where, q = volumetric rate of flow; C_R = rotameter orifice coefficient; A = cross-sectional area of orifice (annular space between spherical float and tube); g = acceleration due to gravity; ΔH = pressure drop expressed in head of *fluid flowing*.

ROTAMETERS WITH SPHERICAL FLOATS

The dimensions of the flowmeter usually are expressed in terms of a diameter ratio (R) and weight of float (W_f) defined as:

$$R = \frac{D_t - D_f}{D_f} \times 100 \qquad (2)$$

$$W_f = \frac{\pi}{6} D_f^3 \rho_f \qquad (3)$$

For the cross-sectional area of the annulus:

$$A = \frac{\pi}{4} (D_t - D_f)^2 = \frac{\pi}{4} (D_t - D_f)(D_t + D_f) \qquad (4)$$

$$\text{From (2): } D_t = \frac{RD_f}{100} + D_f \qquad (5)$$

Substituting equation (5) in (4):

$$A = \left(\frac{\pi}{4}\right)\left(D_f^2\right)\left(\frac{R}{100}\right)\left(\frac{R}{100} + 2\right) \qquad (6)$$

Equating the upward and downward forces on the spherical float:

Downward force due to float weight = Vol. of sphere x Density of sphere = $\pi D_f^3 \rho_f / 6$

Upward force due to buoyancy = Vol. of sphere x Density of fluid = $\pi D_f^3 \rho / 6$

Upward force due to Δ H (neglecting frictional effacts) = pressure differential x area
= (fluid head) (fluid density) (area)
= $(\Delta H)(\rho)(\pi D_t^2/4)$

Equating these forces (as is true when the float is stationary):

$$\left(\Delta H\right)\left(\frac{\pi D_t^2}{4}\right)\left(\rho\right) + \frac{\pi}{6}\left(D_f^3\right)\left(\rho\right) = \frac{\pi}{6}\left(D_f^3\right)\left(\rho_f\right)$$

$$\Delta H = \left(\frac{\pi}{6}\right)\left(D_f^3\right)\left(\rho_f - \rho\right) \Big/ \left(\frac{\pi}{4}\right)\left(D_t^2\right)\left(\rho\right)$$

$$\Delta H = \left(\frac{2}{3}\right)\left(D_f\right)\left(\frac{\rho_f - \rho}{\rho}\right) \qquad (7)$$

Inserting (6) and (7) into (1):

$$q = C_R \pi \left(\frac{R}{200}\right)\left(\frac{R}{100} + 2\right) D_t^2 \sqrt{\frac{g}{3}\left(\frac{\rho_f - \rho}{\rho}\right) D_f} \qquad (8)$$

Inserting (3) in (8)

$$q = C_R \left(D_f\right)\left(\frac{R}{100}\right)\left(\frac{R}{100} + 2\right)\sqrt{\frac{\pi g W_f (\rho_f - \rho)}{2 \rho_f \rho}} \qquad (9)$$

Using q = 980 cm/sec^2, W_f in grams, D_f in inches, ρ in gms/cc, R and C_R dimensionless, q (in cc/min) becomes:

$$q = 59.8\, C_R R \left(\frac{R}{100} + 2\right)\left(D_f\right)\sqrt{\frac{W_f (\rho_f - \rho)}{\rho_f \rho}} \qquad (10)$$

This is a generalized flow equation for a rotameter with a spherical float, in which all terms are physical dimensions and properties, except C_R.

Using Stokes' Law to Modify Reynold's Number

The rotameter orifice coefficient C_R is a function of Reynolds number—which, for an annulus, may be taken as $\rho V (D_t - D_f)/\mu$—and the ratio of diameter of tube to that of float. One difficulty is that the Reynolds number includes the *flow rate*, which thus is the only remaining unknown in equation 10.

DR. ROGER GILMONT is Adjunct Professor of Chemical Engineering at Polytechnic Institute of Brooklyn and President of Roger Gilmont Instruments, Inc.

PAUL MAURER is Senior Engineer with C. F. Braun.

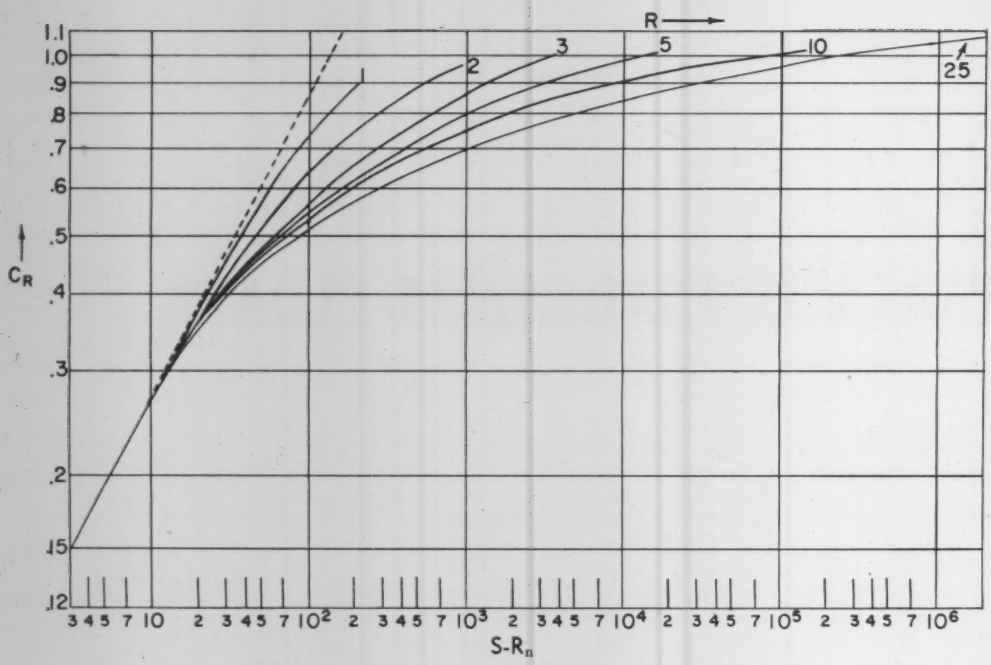

FIG. 1. RELATIONS between C_R and S-R_n at different values of R. For S-R_n less than 5, $C_R = 0.0852\sqrt{S-R_n}$ (dotted line).

A trial-and-error method can be used to obtain the correct orifice coefficient for the flow to be calculated. However, in order to eliminate the trial-and-error approach, the Reynolds number, $\rho V(D_t - D_f)/\mu$, can be modified by applying Stoke's Law—that is, by using "terminal velocity" for the "V" factor in Reynolds number. In other words, the motion of the fluid past the float in the tube can be considered as the terminal velocity of a falling sphere because there is no difference between fluid flowing upwards past a stationary ball and a ball falling downwards through stationary fluid. The Reynolds number modified according to Stoke's law will be referred to as the Stokes-modified Reynolds number (S-R_n):

$$\text{S-}R_n = \frac{\rho\,(D_t - D_f)\,V_t}{\mu} \qquad (11)$$

where V_t = terminal velocity.

According to Stokes' law the terminal velocity of a sphere falling through a fluid is given by:

$$V_t = \frac{g\,(D_t - D_f)^2\,(\rho_f - \rho)}{18\mu} \qquad (12)$$

Substituting (12) in (11):

$$\text{S-}R_n = \frac{g\,(D_t - D_f)^3\,\rho\,(\rho_f - \rho)}{18\mu^2} \qquad (13)$$

Reynolds number now is expressed in terms of known quantities—physical properties of the fluid and dimensions of the flowmeter.

Substituting (2) and (3) in equation 13 gives:

$$\text{S-}R_n = \frac{g\rho\,(\rho_f - \rho)\,W_f\,R^3}{(3 \times 10^6)\,\pi\,\rho_f\,\mu^2} \qquad (14)$$

If W_f is in grams, ρ and ρ_f in grams/cc, μ in centipoises, g = 980 cm/sec^2, and R dimensionless, equation (14) becomes:

$$\text{S-}R_n = \frac{1.042\,W_f\,(\rho_f - \rho)\,R^3}{\mu^2\,\rho_f} \qquad (15)$$

We now have a form of Reynolds number in which all factors are easily measurable physical parameters.

Generalized Correlation

Experimental measurements were made to utilize equations (10) and (15) to obtain curves relating C_R, S-R_n, and R. These values were obtained in measurements taken with five meters with spheres of 1/16″, 1/8″, 1/4″, 3/8″ and 1/2″ in diameter. The two larger sizes were beaded tubes to give stability at large values of R; the three smaller sizes were plain tapered tubes. All five tubes covered values of R from 1 to 25. Most data were obtained with air and water. Some check runs were made with organic liquids to cover the range of low viscosity and high density.

The results of these measurements are plotted in Fig. 1 as C_R *vs* S-R_n on logarithmic coordinates, with R as a parameter. One remarkable characteristic of this generalized plot is that all the curves blend into a single straight line at values of S-R_n below 5. According to Stokes' law, at these low values of S-R_n, one would expect a series of parallel straight lines for different values of R, if the assumption of an equivalent diameter based on Poiseuille's law is made. However, within experimental error the data appear to give a single straight line in the above region. At values of R approaching 25, the data appear to be slightly higher than the line, but do not deviate more than the experimental error. In order to verify the existence of a single straight line in the region of S-R_n less than 5, additional experimental work employing highly viscous Newtonian liquids are contemplated.

Note that at high values of S-R_n the flow coefficient C_R exceeds the value of unity. This is due to the fact that at high rates of flow the frictional effects are significant, so that the true value of ΔH is greater than that assumed in the correlation.

VALVE TIPS:

How to Select Automatic Regulating Valves For Temperature Control

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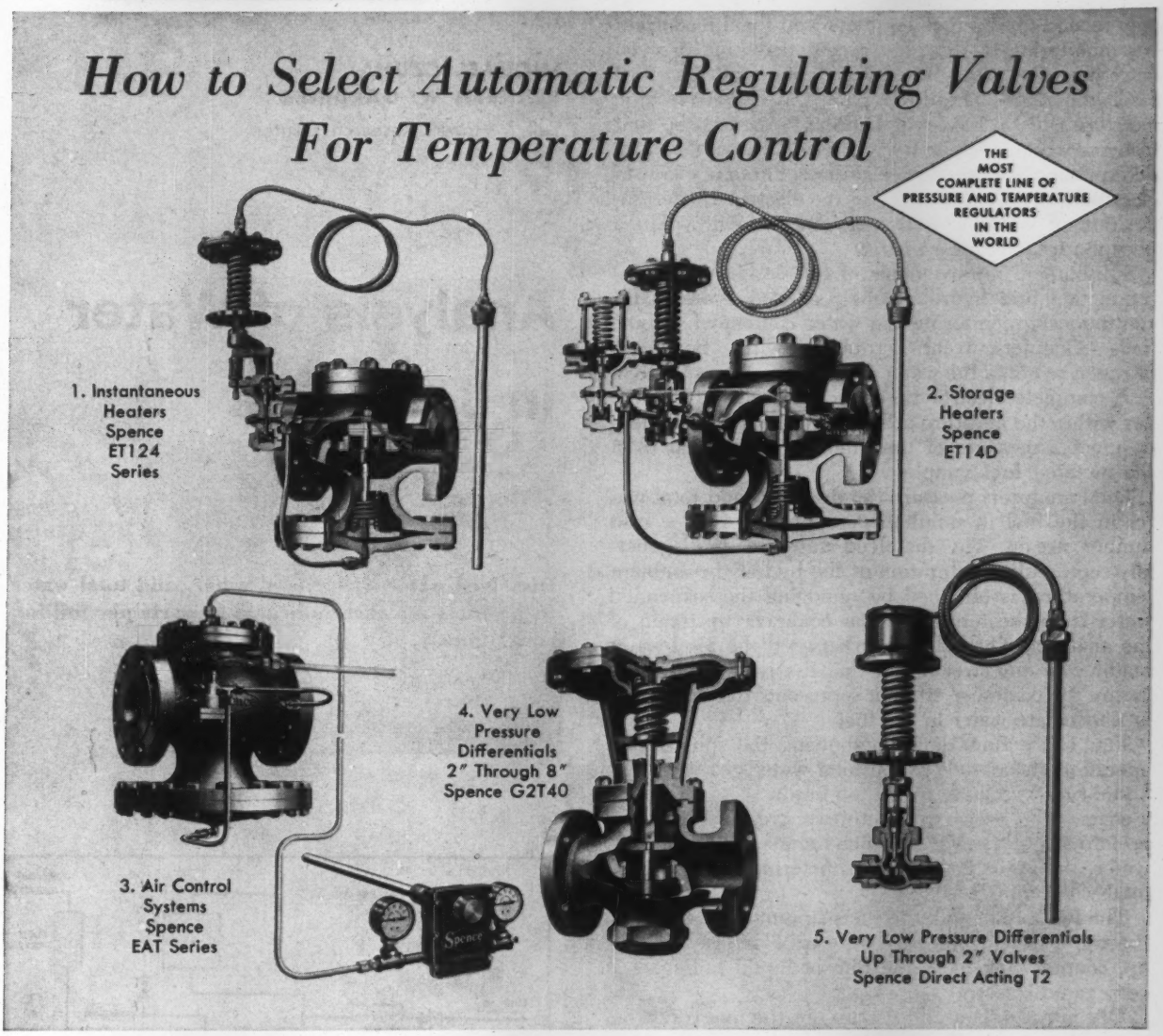
1. Instantaneous Heaters Spence ET124 Series
2. Storage Heaters Spence ET14D
3. Air Control Systems Spence EAT Series
4. Very Low Pressure Differentials 2" Through 8" Spence G2T40
5. Very Low Pressure Differentials Up Through 2" Valves Spence Direct Acting T2

During the past year, our field representatives have reported many cases of improperly, and uneconomically, applied temperature regulators. To help you avoid some of these costly mistakes, here are a few tips on selecting the most effective and economical temperature regulating valves for your applications.

1. Instantaneous heaters require a special action for close temperature control and freedom from hunting. In the Spence ET124 series, steam pressure is modulated according to temperature (demand) and is automatically regulated at any pressure established by the demand.
2. Storage heaters, on the other hand, are more economically controlled by the Spence ET14D, which includes a simple temperature-actuated pilot that opens and closes the main valve to maintain a constant temperature.
3. Air control systems can now have a ±5°F control accuracy under wide and instantaneous load swings with the Spence EAT regulator. Engineers report savings of up to 50% in installed costs with this recently developed Spence cascade system when it has been used in place of conventional instrumentation.
4. For the combination of very low pressure differentials and air or water control, Spence recommends Type G2T40. This single seated pilot operated valve provides fast, positive response in 2" through 8" valves. Double seat Type G22 is also available in 10" through 12".
5. When very low pressure differential is encountered with valves of 2" or less, the Spence direct operated T2 is recommended. The sensitive vapor tension thermostat responds quickly to small changes in bulb temperature for continuous, accurate control.

In this brief description of industrial process and heating temperature control, we have given a few important tips in proper regulator selection. If you would like more detailed information on these control applications, write for the new Spence Temperature Control Bulletin IV 1014. SE-150

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Analysis of Water in Jet Fuels

Dissolved water, suspended water, and total water in jet fuels are each indicated in parts per million continuously.

ALTHOUGH the Karl Fischer wet-chemical method has been used extensively for the analysis of dissolved water samples of hydrocarbons, only recently has a technique evolved for the continuous monitoring of process streams, matching or even bettering the precision and accuracy of the Karl Fischer method. The development of the *electrolytic moisture cell* by Keidel at DuPont [1] marked the first instance where coulometry was used in absolute water determinations. The device utilizes Faraday's law of electrochemical equivalency in the electrolytic decomposition of water to hydrogen and oxygen within a phosphoric anhydride matrix.

Subsequent improvements in cell design and adaptation to liquid hydrocarbons [2] offered a means for continuously monitoring the water content of turbine fuels. Counter-current scrubbing with "bone-dry" nitrogen removes the water from the fuel quantitatively [3]; complete electrolytic dehydration of the effluent gas within the moisture cell with 100% current efficiency gives a measure of the total water removal from the metered fuel sample.

Dual analyzers measure the dissolved and total water in the fuel in simultaneous operations on a split sample stream. The dissolved-water reading, generally representing saturation of the fuel at the ambient temperature, is obtained by removing the suspended water from the fuel in a filter coalescer upstream of the analyzer. The difference between the total-water reading on one stream and the dissolved-water reading on the coalescer effluent represents the suspended or particulate water in the fuel.

Fig. 1 is a flow diagram showing the split stream operation and details of the total water analyzer. The liquid fuel is brought in (at top left in Fig. 1) through a coarse filter and is split into two streams, one going up into a filter coalescer, which removes all suspended water, the other going to the metering pump on the total-water analyzer.

The fuel is pumped into the stripping column where the water is removed by a stream of dry gas flowing up, counter current to the film of liquid falling on a corrugated surface.

Dry nitrogen is used to scrub out the moisture from the fuel and also to actuate the metering pump. Provision also is made to utilize the nitrogen gas pressure in a spring-loaded piston-driven valve (at top left) which shuts off the fuel at the inlet when the gas pressure fails, preventing flooding of the analyzer.

The nitrogen is completely dried within an electrolytic cell (lower left) identical with the sensing cell. Part of the gas diverted to the metering pump is used to flush the fuel sample from the valve cavity into the stripping column.

Fig. 3 shows the Model 26-312 analyzer assembly used for single-stream analysis.

Fig. 2 shows the tubular electrolytic cell which removes all the water from the gas stream and converts it to hydrogen and oxygen with 100% current efficiency. The cell is made of glass capillary tubing about 3′ long and 0.020″ inside diameter, and contains a bifilar winding of platinum wire. The inner surface is coated with phosphorus pentoxide which acts as both desiccant and electrolyte. Voltage applied across the platinum electrodes results in electrolysis of the hydrated coating and conversion of the absorbed water to hydrogen and oxygen. The current flowing through the cell is a measure of the water picked up from the gas stream. At the design fuel sample flow rate of 0.215 ml/min, the equivalent current is approximately 30 μamp/ppm H_2O.

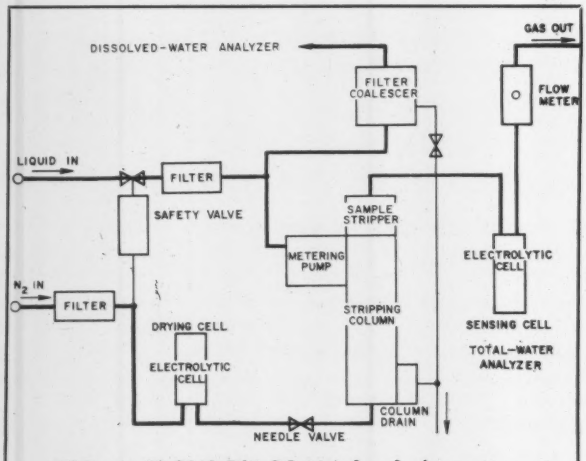

FIG. 1. FLOW DIAGRAM for fuel monitor.

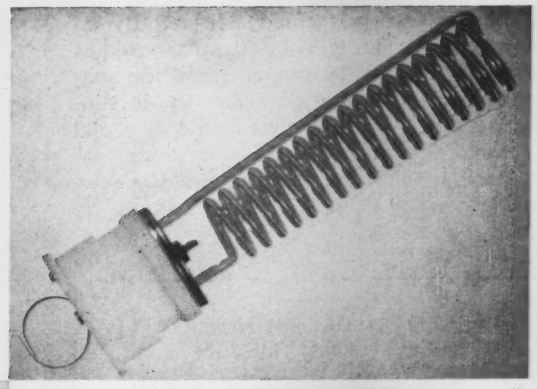

FIG. 2. **ELECTROLYTIC** sensing cell.

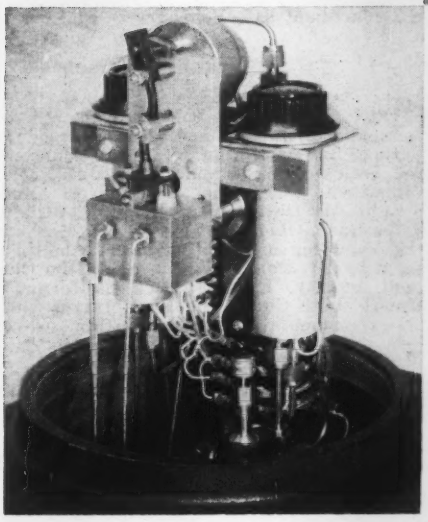

FIG. 3. ANALYZER Model 26-312, showing metering pump.

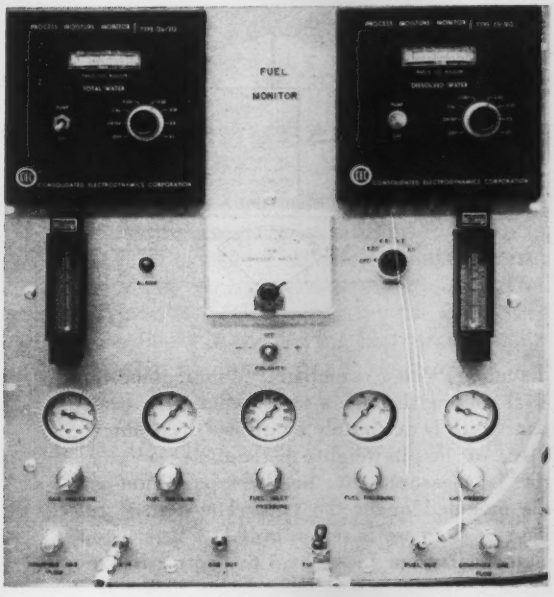

FIG. 4. FRONT PANEL of fuel monitor.

The difference between the total-water and dissolved-water signals is read on the meter shown at center in Fig. 4 and represents the suspended water in the fuel. A sensitive meter relay with automatic reset sounds an alarm when a preset level of suspended water is exceeded. Total water is indicated at upper left, and dissolved water at upper right.

Performance

Table 1 shows analyses correlating some analyzer readings on total water with Karl Fischer analyses. Considerable sampling difficulties were experienced with the Karl Fischer method on suspended water samples, so no attempt at a statistical correlation was made.

Although the analyzer performed satisfactorily on JP-4 and RP-1 fuels, certain glycol derivatives used as anti-icing additives caused positive errors in the analyzer response. Methyl carbitol, for example, in concentration between 0.1% and 0.2% gave a reading of 100 ppm in JP-4 containing 80 ppm water. The exact nature of this interference is not understood; however, it is known that certain alcohols respond as water in the electrolytic cell.

TABLE I—CEC MOISTURE MONITOR VS KARL FISCHER ANALYSIS ON TOTAL WATER IN JP-4.

Run	CEC	Karl Fischer
1	49	47
2	68	62
3	5	12
4	72	74
5	33	33
6	120	116

The accuracy and reproducibility of the method is comparable to that of the Karl Fischer method. The instrument is useful in measuring rapid changes in the water content of the fuel.

The principle of differential electrolysis may be extended to other systems in which a difference in moisture levels between two streams is to be monitored.

References

1. Keidel, F. A., "Determination of Water by Direct Amperometric Measurement," *Analytical Chemistry*, Vol. 31, page 2043, 1959.
2. Cole L. G., M. Czuha, R. W. Mosley, and D. T. Sawyer, "Continuous Coulometric Determination of Parts per Million Moisture in Organic Liquids," *Analytical Chemistry*, Vol. 31, page 2048, 1959.
3. Krynitsky, J. A., "Theoretical Considerations Governing the Dehydration of Fuels by Gas Blowing," Naval Research Laboratory, Washington, D. C., NRL Memo Department 648, February, 1957.

Acknowledgments

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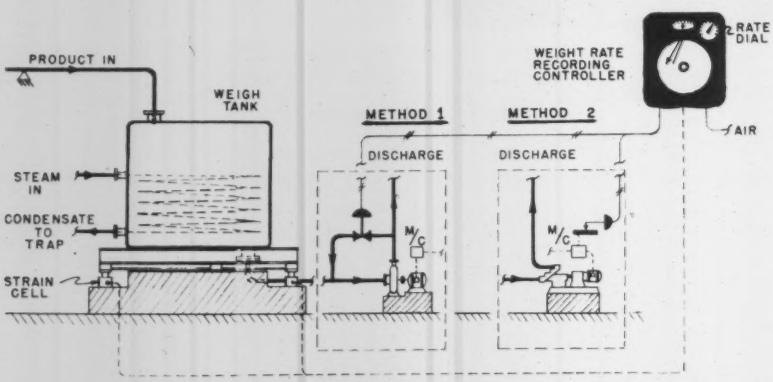
Acknowledgement is made of the helpful assistance given by Dr. Donald T. Sawyer of the Chemistry Department faculty, University of California, Riverside, and Messrs. John Curtis and Earl Martin who participated in the experimental design and testing.

FLOW IN BATCH PROCESS CONTROLLED BY STRAIN CELL AND LOSS-IN-WEIGHT TECHNIQUE



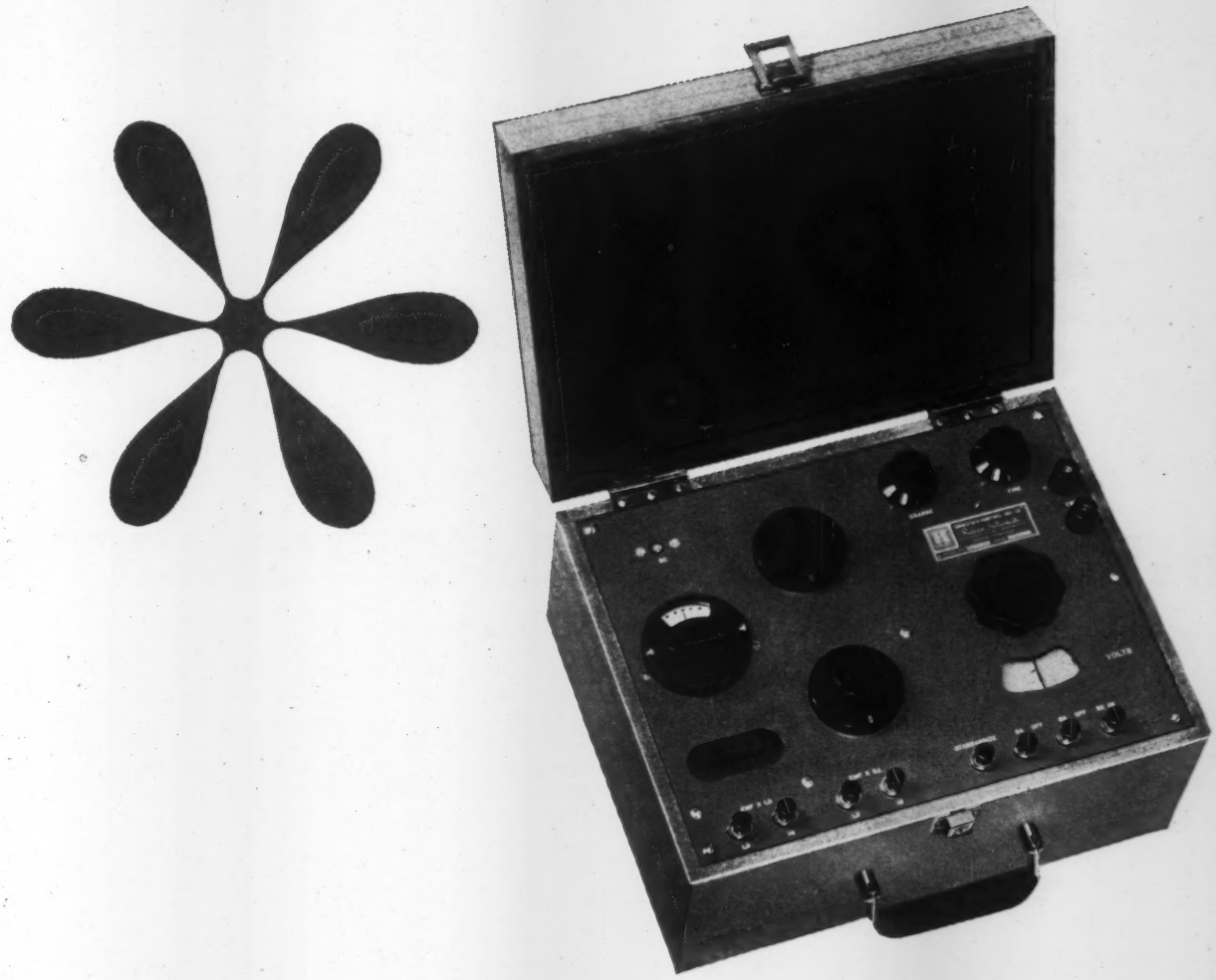
At Hercules Powder Company, Wilmington, flow of material passing through a tank (where it is heated by a steam coil) is accurately controlled by using the weight-rate, or loss-in-weight, method.

Weight is measured by bonded-type strain-gage load cells mounted under the tank. The desired *rate* of increase or decrease is set on a dial. A "start-stop" timer motor pulses an index arm to control the motion rate of a driven index. The relation of the position of the pen to that of the driven index governs the pneumatic output of the weight rate controller to the controlled mechanism, allowing more or less volume of material to pass from the vessel at the desired rate of flow.

Two methods in common use are shown. In method one (use for acids and heavy slurries) a pump runs at constant speed, flow rate is controlled by by-passing liquid back to suction through a control valve. The other method (used for highly-viscous materials, mostly at higher temperatures), employs a positive-displacement pump driven by a d-c motor. Here, the motor speed is controlled directly by a pneumatically controlled slidewire. In both systems the pneumatically operated slide wire and control valves receive their actuating signal from a pneumatic weight-rate controller with proportional and reset control motion. Primary signals come from the strain gages under the tank.

Equipment used: Electronic recorder with pneumatic control output (Foxboro); load cells, Type SR-4 (Baldwin-Lima-Hamilton Corp.); control valves; accessories.

Source: Lee Barnette, Hercules Powder Company, Wilmington, Del.; also ASME Paper No. 53-IRD-12.



HOW SHOULD YOU EVALUATE POTENTIOMETER ACCURACY?

Accuracy in an instrument is more than a matter of how closely measured values correspond to true values. Some potentiometers, for example, may be capable of sky-high accuracy—but only under ideal laboratory conditions. Other potentiometers may deliver consistent high accuracy . . . higher than you actually need . . . with the penalty of excessive cost.

A realistic evaluation of potentiometer accuracy, then, involves consideration of stability and reproducibility as well as stated limits of error. By these criteria, Rubicon potentiometers, galvanometers and bridges should be YOUR choice.

Rubicon accuracy stems from a long tradition of engineering excellence and a pride of craftsmanship that is not easily found these days. You can sense this about Rubicon instruments, even before you put them to work. And today the Rubicon tradition of the finest in measuring instruments is being perpetuated by both small refinements and major advances in design . . . to make the best even better. The complete line of Rubicon instruments is available through any of the Honeywell branch offices across the nation.

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By any measure, the new Rubicon 2746 *portable* potentiometer is an outstanding instrument. Ranges 0—1.601 and 0—0.1601 volts. Limits of error are constant, realistic, usable: high range—30 microvolts or 0.03% of reading, whichever is larger. Low range—3 microvolts or 0.045% of reading, whichever is larger. Depend on it for *consistent* accuracy. **Write for Specification Sheet RS-2746, for details.**

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DIFFERENTIAL MEASUREMENTS

When measurements involve only a selected span, such as monitoring the speed of a machine or a high temperature, the lower part of the scale only reduces the resolution and readability of the indication. Higher resolution can be achieved by suppressing the lower part of the scale or by using differential-measurement technique. Here are three basic differential techniques—(1) series differential, (2) parallel differential, and (3) differential bridge. The bridge is the most flexible technique.

IN THE simple *series differential circuit* (Fig. 1), two emf sources (E_1 and E_2), indicator M, and the limiting resistor R_s are connected in series, with the emf of the sources opposing each other. Let us assume that the sources are tachometer generators for speed measurement, although the discussion applies to sources for any type of measurement.

The indicator current i, which is the difference between the source currents, is:

$$i = \frac{E_2 - E_1}{r_1 + r_2 + R_s + r} \qquad (1)$$

where r_1 and r_2 are internal resistances of the sources, and r the resistance of the indicator.

There is a null condition (no current) when $E_1 = E_2$. Equal emf's of the generators produce zero deflection of the meter and indicate equal speeds. If the speeds differ, then current i flows in proportion to the speed difference. This is arrangement of a *differential tachometer*. Such a tachometer, when equipped with an indicator having zero in the center of the scale, shows not only the speed difference, but also which speed is higher.

Scale Suppression

If one of the generators is replaced by a fixed reference source, such as a mercury battery, or Zener-diode-controlled reference source, the indicator null will occur when the operating generator produces an emf equal to that of the reference source. A milliammeter or microammeter, with mechanical zero either in the middle or at the end of scale, can be used as an indicator. This is the arrangement of a *high-resolution tachometer with lower speeds suppressed by the reference source*. The more sensitive the indicator used, the higher the resolution of reading. A similar technique is used in "bucking off" indications, for instance, in differential voltmeters with electrically suppressed zero.

The generators used in the circuit in Fig. 1 must have identical emf-versus-speed characteristics. If they do not, null will occur at unequal speeds. Changing the circuit resistance will not help, and only adjustment of the generator emf can correct such a faulty situation. For this reason the use of a-c generators in this simple series differential arrangement is impractical. Only d-c generators equipped with a magnetic shunt for emf adjustment are recommended with this arrangement.

The system can be made more manageable if resistances R_3 and R_4 are added as shown in Fig. 2, with series resistance R_s split into R_1 and R_2. In this

*Formerly R&D Tachometer Systems Chief, Weston Instruments Div.; now Project Engineer, Central Research Laboratory.

Based in part on paper presented at AIEE Winter General Meeting, New York City, Jan. 30, 1961.

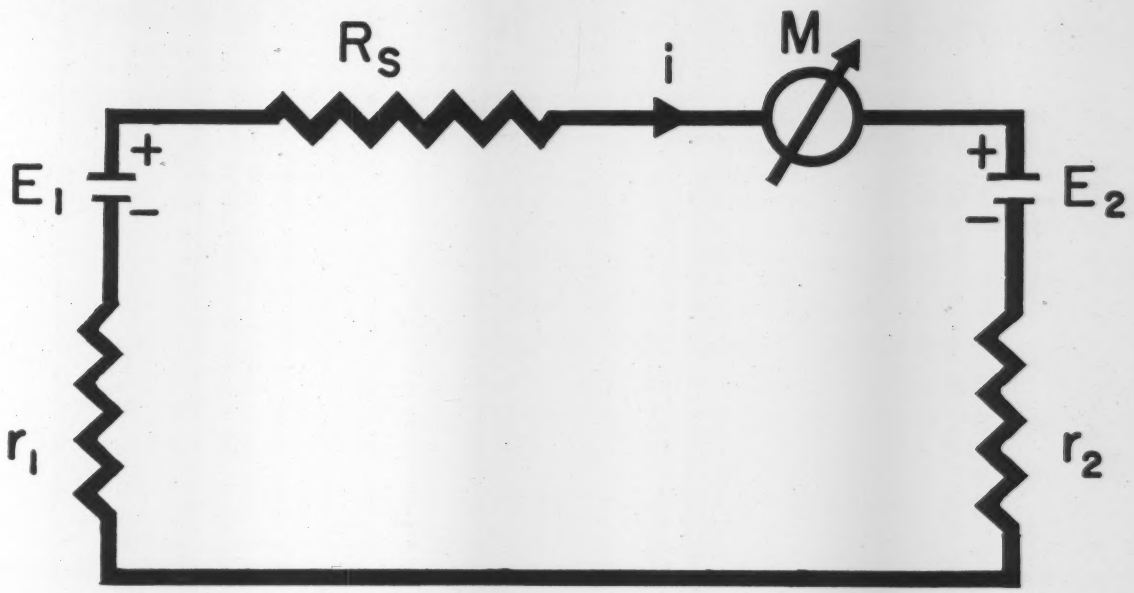

FIG. 1. SERIES DIFFERENTIAL circuit.

differential tachometer, the indicator current i can be computed from the following loop equations:

$$E_1 = I_1 (R' + R_3) - iR_3 \quad (2)$$

$$E_2 = I_2 (R'' + R_4) + iR_4 \quad (3)$$

$$0 = i (r + R_3 + R_4) - I_1R_3 + I_2R_4 \quad (4)$$

where $R' = R_1 + r_1$ and $R'' = R_2 + r_2$. When I_1 and I_2 are found from Eqs. 2 and 3 respectively, and substituted in Eq. 4, expression (5) for i results:

$$i = \frac{E_1 \frac{R_3}{R' + R_3} - E_2 \frac{R_4}{R'' + R_4}}{r + \frac{R'R_3}{R' + R_3} + \frac{R''R_4}{R'' + R_4}} \quad (5)$$

The indicator current now is proportional to the difference between the potential at point L (created by source E_1, in the absence of the rest of the circuit to the right of point L) and the potential at point O (created by the source E_2 in the absence of the rest of the circuit to the left of point O). This potential difference is divided by the sum of three resistances—(1) that of the indicator, r, (2) that of the parallel combination of the resistances R′ and R_3 in the loop of the source E_1, and (3) that of the parallel combination of the resistances R″ and R_4 in the loop of the source E_2.

Null (i = 0) occurs if:

$$E_1 \frac{R_3}{R' + R_3} = E_2 \frac{R_4}{R'' + R_4}$$

Thus the condition for balance can be written:

$$\frac{E_1}{E_2} = \frac{R_4 (R' + R_3)}{R_3 (R'' + R_4)} \quad (6)$$

Such a modified series differential arrangement, therefore, can be balanced by adjusting resistors to obtain a current null when the two generators are driven at equal speed. In order to make i large, one has to choose a high value for R_3 and R_4 and a low value for R′ and R″. With R_3 and R_4 of high value, the circuit in Fig. 2 reduces to that of Fig. 1.

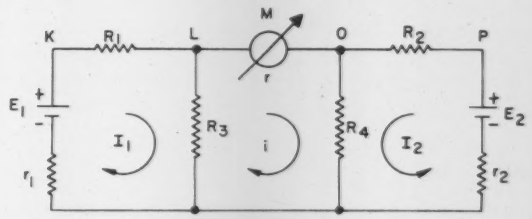

FIG. 2. MODIFIED series differential circuit.

For a tachometer with lower speeds suppressed, the indicator current is the current caused by generator emf above that of the reference emf. It can be computed directly from Eq. 5, after substituting ΔE_1 for E_1 and 0 for E_2:

$$i' = \frac{\Delta E_1 \frac{R_3}{R'' + R_3}}{r + \frac{R'R_3}{R' + R_3} + \frac{R''R_4}{R'' + R_4}} \quad (7)$$

Parallel Differential Arrangement

In the circuit in Fig. 3 the emf's are connected so as

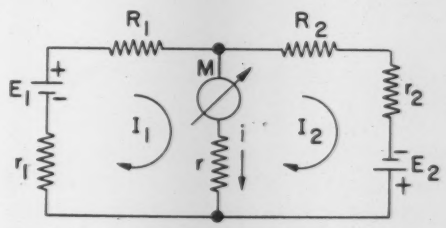

FIG. 3. PARALLEL DIFFERENTIAL circuit

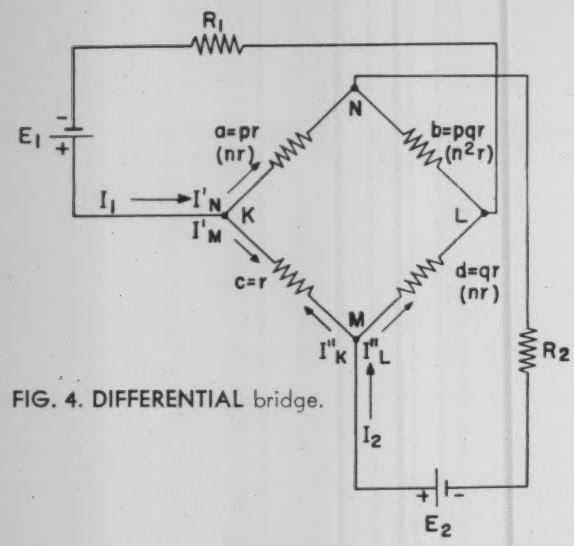

FIG. 4. DIFFERENTIAL bridge.

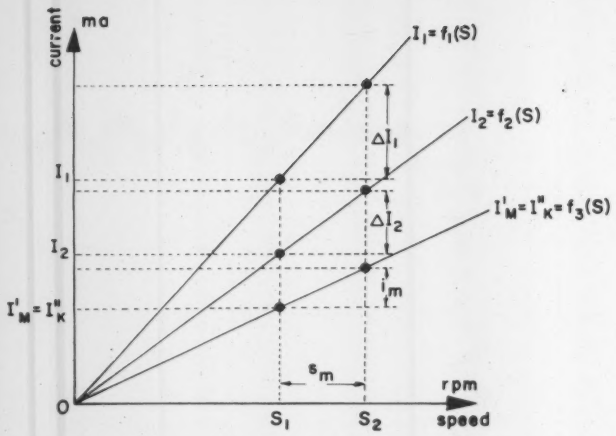

FIG. 5. CHARACTERISTICS of current as a function of speed.

to help each other. However, in the indicator branch, parallel with the sources, the currents I_1 and I_2 flow in opposition. The loop equations for this circuit are:

$$E_1 = I_1 (r + R') - I_2 r \qquad (8)$$
$$E_2 = I_2 (r + R'') - I_1 r$$

where r is the indicator branch resistance, $R' = R_1 + r_1$ and $R'' = R_2 + r_2$. These yield

$$I_1 = \frac{E_2 r + E_1 (r + R'')}{r (R' + R'') + R'R''}$$
$$I_2 = \frac{E_1 r + E_2 (r + R')}{r (R' + R'') + R'R''} \qquad (9)$$

The differential tachometer indicator current i, which is the difference between the loop currents, will be:

$$i = I_1 - I_2 = \frac{E_1 R'' - E_2 R'}{r (R' + R'') + R'R''} \qquad (10)$$

There will be no current in the indicator if

$$I_1 = I_2, \text{ or } E_1 R'' = E_2 R'$$

whence the condition for balance is:

$$\frac{E_1}{E_2} = \frac{R'}{R''}, \text{ or } \frac{E_1}{R'} = \frac{E_2}{R''}$$

This circuit also can be balanced by adjustment of resistors.

The indicator current i' in a tachometer with lower speeds suppressed again can be computed from Eq. 10 after substituting ΔE_1 for E_1 and 0 for E_2:

$$i' = \frac{\Delta E_1 R''}{r (R' + R'') + R'R''}$$
$$= \frac{\Delta E_1}{r \frac{R'}{R''} + r + R'}$$

In order to make i' large for a given signal increase, one has to choose an indicator with a low resistance r, make the resistance of the signal source low, while the resistance of the reference circuit is made high. It is advantageous to use a high reference voltage, or Zener diode with a high breakdown voltage, which would call for a high value of R_2.

The parallel differential circuit offers more flexibility than the series one. Adjustment of R_1 and R_2 can produce a null in the indicator. This is when the lower end of the measured speed band coincides with zero deflection on the indicator. Adjustment of the resistance r in series with the indicator can bring the pointer to full scale deflection at the top speed.

Differential Bridge

The most flexible arrangement for differential emf measurements is a *bridge* (Fig. 4), composed of four resistances a, b, c and d, with two sources E_1 and E_2 connected to the opposite corners of the bridge.

If the bridge is balanced so that values of resistance are selected to make:

$$ad = bc \qquad (11)$$

then the potential difference between points M and N due to source E_1, and the potential difference between points K and L due to source E_2 are both zero. *Each source circuit is independent of the other, and changes in one circuit current will not affect the current in the other circuit.* This is why this bridge has been used for many years in phantom circuits in communication.

Inside the bridge, however, the currents mix with each other. In one pair of opposite resistors the components of the currents flow in the same direction, while in the other two resistors they flow in opposition. If a galvanometer is located in one of the latter arms, it can detect the null condition, or measure difference between these components.

Fig. 5 shows two linear characteristics of two emf generators (tachometers) as a function of speed: $I_1 = f_1(S)$ and $I_2 = f_2(S)$. It is evident that at any particular speed the generators produce different currents so that direct comparison is not possible. However, the bridge offers the possibility of splitting each source current into two components, and making one of these components of one source current equal to one component of the other source current. In this way the speeds can be compared not in terms of the total currents of the sources, but in terms of their respective components. The arms of the bridge have to

be selected to allow this splitting of current to take place.

The condition of balance reduces the number of the bridge parameters to three. Rewriting expression (11) for balance in the bridge in the form of resistance ratios, and calling these ratios p and q:

$$\frac{a}{c} = \frac{b}{d} = p, \tag{12}$$

$$\frac{d}{c} = \frac{b}{a} = q, \tag{13}$$

one can express the arms of the bridge in terms of one arm resistance, say $c = r$,, and of the factors p and q as:

$$\begin{aligned} c &= r \\ a &= pr \\ d &= qr \\ b &= pqr \end{aligned} \tag{14}$$

where r is a resistance in ohms, and factors p and q can be any positive, real number.

The resistance r of the indicator is chosen as the arm c value. The indicator is located between points K and M, to which the positive terminals of the emf sources are connected. It is evident that the component I'_M of the current I_1 which flows through the indicator branch KML is p times as large as I'_N flowing through the branch KNL, because the resistance of the branch KML is $(r + rq)$, while that of the branch KNL is $p\ (r + rq)$. Similarly the component I''_K of the current I_2 that flows through the indicator is q times as large as I''_L.

The factors p and q as expressed in terms of these currents are:

$$p = \frac{I'_M}{I_1 - I'_M} \tag{15}$$

$$q = \frac{I''_K}{I_2 - I''_K} \tag{16}$$

With help of the characteristics in Fig. 5, the two different values of the two source currents I_1 and I_2 at any particular speed S_1 can be determined. The values I'_M and I''_K, equal to each other, can be chosen next as the parts of I_1 and I_2. Substitution of these values into Eqs. (15) and (16) determines p and q, and hence the whole bridge.

In such a bridge, if the two generators' emf vary in unison, the currents in the indicator arm will vary as the characteristic $I'_M = I''_K = f_3(S)$. If, however, one generator emf is constant while the other increases, there would be in their circuits a different current increase ΔI_1, or ΔI_2, depending on which emf is larger. Nevertheless, owing to the bridge design, the increase of current in the indicator arm will be i_m. The indicator deflection will be proportional to the generators' speed difference and can be calibrated in rpm.

It should be noted that although in the NL arm of the bridge the currents also flow in opposition, they do not balance simultaneously with the currents in the indicator arm and are of no value for differential speed measurements.

As was stressed previously, when two generators with different characteristics are used, as shown in Fig. 5, equal currents are not associated with equal emf's. The equality of currents, however, always happens at a one particular ratio of the generator's emf or, conversely, the equality of emf's is associated with a particular ratio of the circuit currents. This property of the bridge might be used in a kind of ratio meter or in a percent deviation meter.

If the characteristics of the generators used in the differential setting are, or can be made, identical, the bridge arrangement can be simplified. For the function $I_1 = I_2 = f(S)$ the factors p and q of the bridge cannot differ. They must be equal:

$$p = q = n$$

In this situation the original four bridge parameters reduce to two only, r and n, and the bridge arms assume values:

$$\begin{aligned} c &= r \\ a &= nr \\ d &= nr \\ b &= n^2 r \end{aligned} \tag{17}$$

The resultant resistance of this bridge is equal to nr for either source. It is advantageous to select a high value factor n. The higher the n value, the greater the current flow through the indicator. It can be shown that if one source current exceeds that of the other by ΔI, then the current through the indicator is:

$$i = \Delta I \frac{n}{n+1} \tag{18}$$

The resistance r of the indicator is copper and as such is subject to changes with temperature. Again a high value of n, resulting in high manganin resistance of the other arms, improves the situation. It can be shown that:

$$\frac{di}{i} = \left(\frac{dr}{r}\right)\left(\frac{1}{n+1}\right) \tag{19}$$

Thus the indicator deflection change due to indicator resistance change is reduced by the factor:

$$\frac{1}{n+1}$$

Although unequal components of ΔI flow in the indicator arm and the opposite arm, the null condition appears in both arms simultaneously, so that the indicator could be located in either arm.

As a particular form of this setting there is the third, the simplest of all bridges, in which $n = 1$; in other words, all arms are equal. There is only one parameter in such a bridge:

$$a = b = c = d = r \tag{20}$$

The resultant resistance r of the bridge is again seen equal by both sources, and inside the bridge the current components are equal.

For the simplicity of this bridge one must pay by a reduced efficiency of indication because, with $n = 1$, only one half of the source current increase appears in the indicator, as is seen from Eq. (18), the other half being lost in the opposite arm.

Applications of the Differential Bridge

The series and parallel arrangements are used in

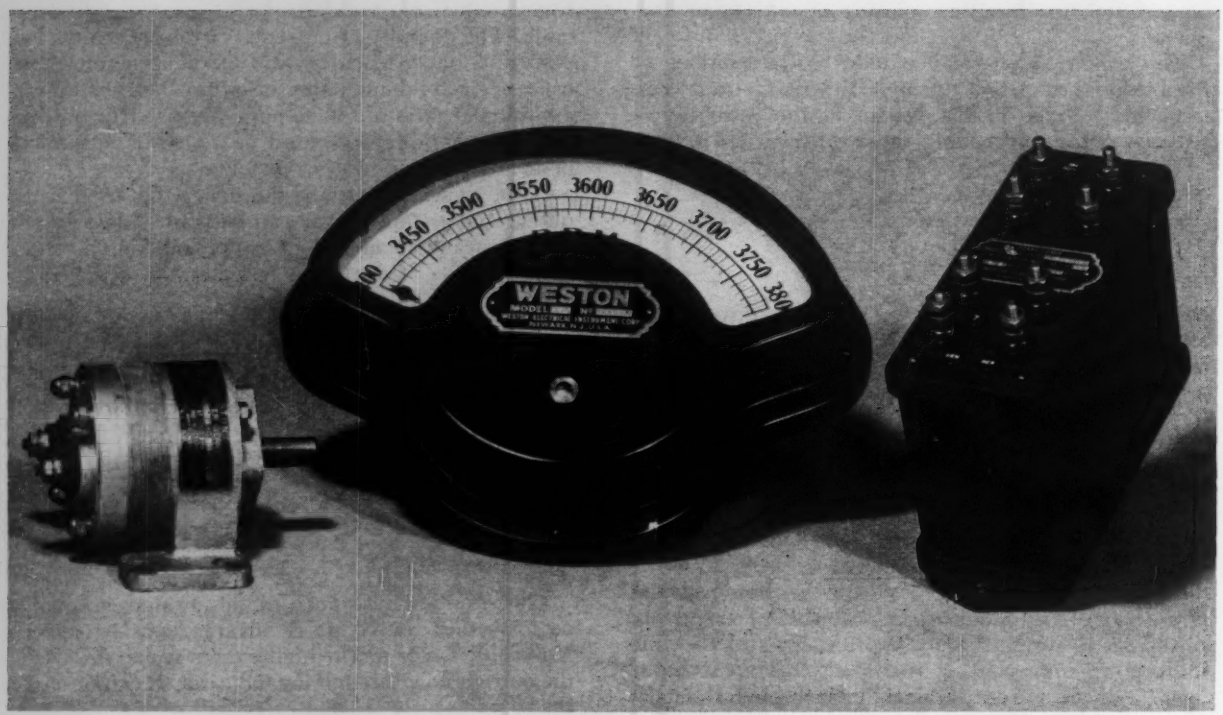

FIG. 6. TACHOMETER for 3400-3800 rpm.

differential speed measurements only when no other alternative exists. The first choice is always the differential bridge.

If the characteristics of the two generators (tachometers) cannot be made identical, the balanced bridge with three parameters must be used in speed comparison. Most often the two generators are of the same type, and they can be adjusted by means of R_s to display identical characteristics. In this case the simpler version of the bridge is a matter of a straight-forward procedure. It depends on the maximum span s_m of speed required to be shown on the indicator scale, and on the chosen instrument sensitivity i_m with resistance r_1. If this is to be a tachometer with lower speeds suppressed, the threshold speed value S_1 also must be known. The problem is to choose and to make the generator characteristics that best comply with these conditions.

The slope of the characteristics (ratio of current to speed) is determined by the speed span s_m, the indicator sensitivity i_m and factor n, as follows:

$$\frac{I}{S} = \frac{\left[i_m \right] \left[\frac{n+1}{n} \right]}{s_m} \qquad (21)$$

Therefore the current I_1, produced by a generator at a particular speed S_1 is:

$$I_1 = \left[i_m \right] \left[\frac{n+1}{n} \right] \left[\frac{S_1}{s_m} \right] \qquad (22)$$

where currents I_1 and i_m are in milliamps, speeds S_1 and s_m are in rpm and factor n is any positive, real number.

If speed S_1 is chosen as the threshold speed value for the tachometer with lower speeds suppressed, the current I_1 will be the current needed from the reference source for suppression.

With the indicator branch resistance equal to r ohms, the resultant resistance of the bridge will be rn and the potential drop across the bridge:

$$V_B = I_1 10^{-3} nr \text{ volts} \qquad (23)$$

The voltage of the reference source must be higher than this value.

Example

Let us consider a high-resolution differential speed indicator displaying a 150-0-150 rpm span of two speed differences.[1] Three instruments were used. Two were conventional indicators associated with the individual generators working within range 0-3000 rpm; the third, shown in Fig. 7, was the actual differential speed indicator. The span s_m was then 300 rpm, the indicator sensitivity 0.225 ma, resistance 250 ohms, $n = 1$, which means all arms of the bridge were equal to meter resistance. Therefore, the source current at a top speed of 3000 rpm, according to Eq. 22, is $I = 0.225 \times 2 \times 2000/300 = 4.5$ ma. This is also the sensitivity of the speed indicators.

It is evident from this example that the high resolution, as a ratio of 300 rpm span to the total angle of the scale, is realized at the cost of very high sensitivity of the instrument. The other two tachometer indicators accommodated 3000 rpm on the same scale angle; they provided poor resolution, but their sensitivity is only 1/20th of the previous instrument.

Another example of the high resolution tachometer, this time with lower speed suppressed, is the 3400-3800 rpm tachometer shown in Fig. 6. The a-c gener-

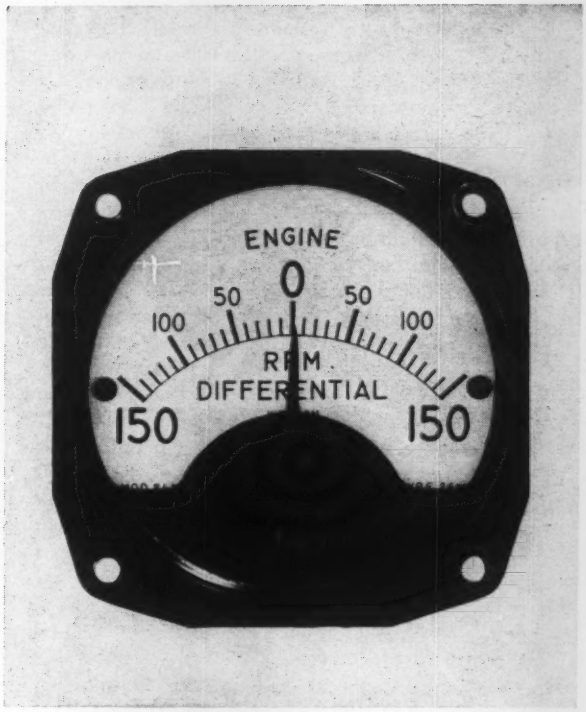

FIG. 7. **DIFFERENTIAL** speed indicator.

ator on the left is connected to the frequency network contained in the box on the right. The output is fed to the differential bridge inside the meter (in the middle). The line voltage, stepped down by a small transformer and rectified, constitutes a reference source, stabilized by a Zener diode (also located in the box). Sensitivity of the meter is 0.5 ma, resistance 250 ohms, n = 1, because all four bridge arms were chosen equal to 250 ohms.

From Eq. 22 the reference current equal to the generator current running at 3400 rpm is:

$$I_{3400} = 0.5 \times 2 \times 3400/400 = 8.5 \text{ ma.}$$

The resultant bridge resistance is 250 ohms. Therefore, the potential drop of the reference current across the bridge is:

$$V_B = 8.5 \times 10^{-3} \times 250 = 2.125 \text{ volts.}$$

The energy for the reference source can be derived not only from an external battery or from an a-c line, but from the same tachometer generator. For instance, in the 11,000-13,000 rpm tachometer, a generator with two windings was used. One winding produced the conventional signal, proportional to speed, while the other supplied reference source that suppressed speeds below 11,000 rpm.[5]

A tachometer with multifold suppression of lower speeds also can be mentioned. Its lowest speed range was 0-500 rpm and did not require a reference current. When speed reached 500 rpm, the reference current was injected into the bridge by a switch, the pointer brought back to the left end of the scale, and the tachometer range was extended from 500 to 1000 rpm. Similarly, by consecutive stepping up the reference, an ultimate range of 4500 to 5000 rpm was reached. Two scale markings were required: one for the first 0-500 rpm range where nonlinearity of the rectifier showed up, and the other for the remaining 9 ranges. The differential bridge in this way permitted the expansion of a 130°, 7″ scale (the basic meter) to 1300° and 70″.

If the reference current were adjusted not in predetermined steps but continuously, any arbitrary speed level could be chosen. An indicator with zero in the center of the scale could indicate not only deviation in rpm, but also whether the generator speed increased above or dropped below the prescribed level.

This deviation can be calibrated on the meter scale not only in rpm but also in percent difference from a chosen value. For instance, the meter can be calibrated −50%, 0, +50% deviation from 1000 rpm, if the generator at 1000 rpm produces a signal current equal to that of the reference. Now, if the current from the reference source is kept constant, but R_s in the generator is altered so that the signal current equals that of the reference when the generator speed is 2000 rpm, then the meter will show the same ±50% deviation of the generator speed—but from 2000 rpm.

Here again R_s could be altered not in steps but continuously, so the meter would indicate percent deviation from any selected speed.

Inclusion of a sensitive relay in the differential bridge, such as Weston Sensitrol relay with magnetic contacts, opens possibilities in control. For instance, this system has found application in printing presses where extreme accuracy and reliability is required in automatic splicing.

As mentioned, the degree of resolution depends on the meter sensitivity. By varying sensitivity of the relay, one can vary the span of deviation of the speed falling within control limits of the device. This can be made conveniently in the bridge by varying resistances c and b simultaneously. Allowing smaller or larger currents to flow through the relay arm, respectively, larger or smaller speed changes actuate the relay.

The potential drop across the meter arm resistance can be fed to a recorder-potentiometer for recording changes in speed.

One bridge or more might constitute arms of another bridge, thus comparing or mixing three or more signals without affecting the signal sources.

An example of the balanced-bridge application in another branch of techniques can be found in reference [4], which describes a bridge as a mixer of two signals in television.

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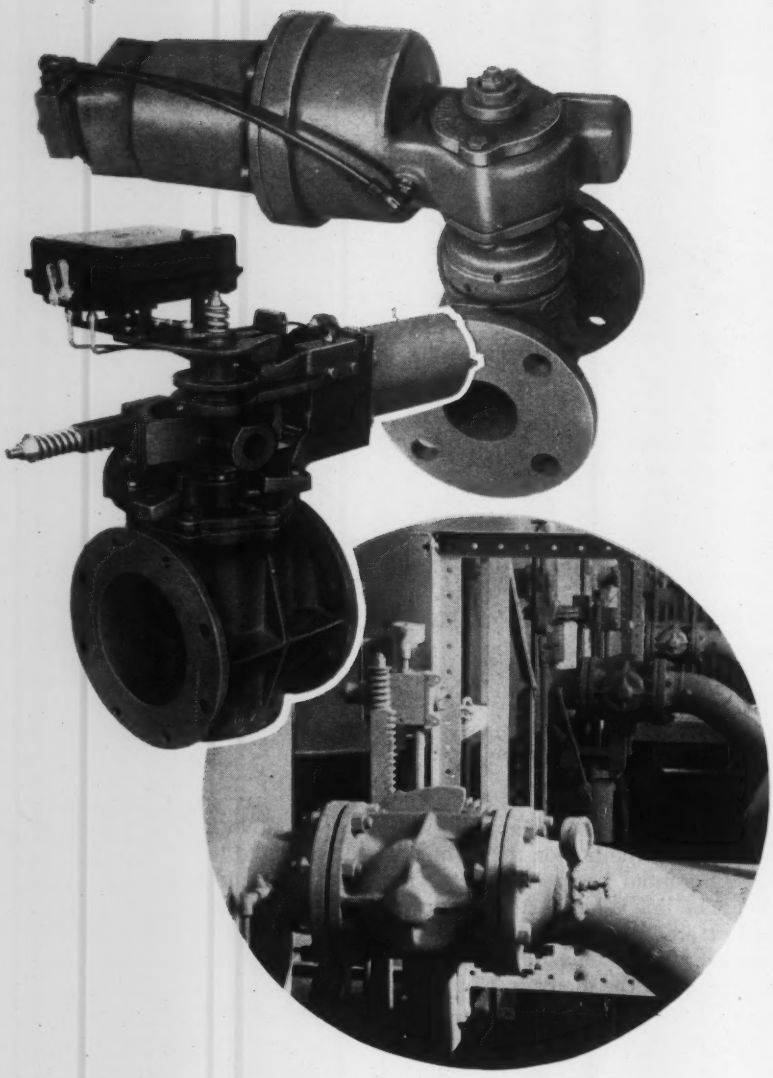

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Gage-Block Interferometer

THE National Bureau of Standards has developed an interferometric comparator that makes routine comparisons of length to the nearest ten-millionth of an inch. Designed by T. R. Young and J. B. Saunders of the Bureau's engineering metrology laboratory, the precise instrument will be used to check lengths of industry's master gage blocks.

At present the Bureau calibrates master gage blocks to an accuracy of 1 part in a million—that is, to the nearest millionth of an inch for inch-long blocks. However, the use of continually smaller tolerances in industry has caused machine-tool manufacturers to request that the Bureau develop procedures for calibrating their master gage blocks on a routine basis to one part in *ten* million.

Like other interferometers, the Bureau's comparator determines the relative positions of reflecting surfaces by means of interference fringes formed by light reflected from these surfaces. However, in this instrument readings are taken directly from a micrometer screw. Thus, greater accuracy is obtained by eliminating visual estimation of fringe displacement.

As the interference fringes can be produced with white light instead of the usual monochromatic sources, the measurement does not depend on the wavelength of light used. This simplifies the measuring procedure. Other advantages of the design are high sensitivity and less instability due to vibration.

The two gage blocks being compared are wrung to the horizontal surface of a flat plate so that they stand on end, side by side, above the plate (Fig. 1). A double prism transmits two beams of collimated white light down onto the top surfaces of the gage blocks and the flat plate. After reflection from these surfaces the two beams are combined at the dividing surface of the double prism, and two separate patterns of interference fringes are formed in the eyepiece of a telescope (Fig. 2). One fringe pattern is within the outline of the superposed images of the gage blocks; the other is formed by the images of the flat plate. If the gage blocks are of equal length, the two fringe patterns will coincide, but if there is a difference in length, the fringe patterns will be proportionately displaced with respect to each other. The observer then uses a micrometer screw to move portions of an optical wedge system until the two fringe patterns successively coincide with the cross hair in the microscope eyepiece. The distance from one point of coincidence to the other is read from the micrometer and converted into the corresponding difference in gage block length by means of a previously determined calibration constant.

Experiments have shown that the calibration constant is sufficiently invariant with wavelength that the full range of the instrument may be used to compare gage blocks differing in length by as much as two ten-thousandths of an inch.

Variables that must be accurately controlled in the absolute measurement include pressure, temperature, and humidity of the air; temperature and thermal expansion coefficient of the gage block material; and the phase change occurring at reflection from the surfaces of the gage block and the flat plate. This phase change is a function of the material and the surface finish.

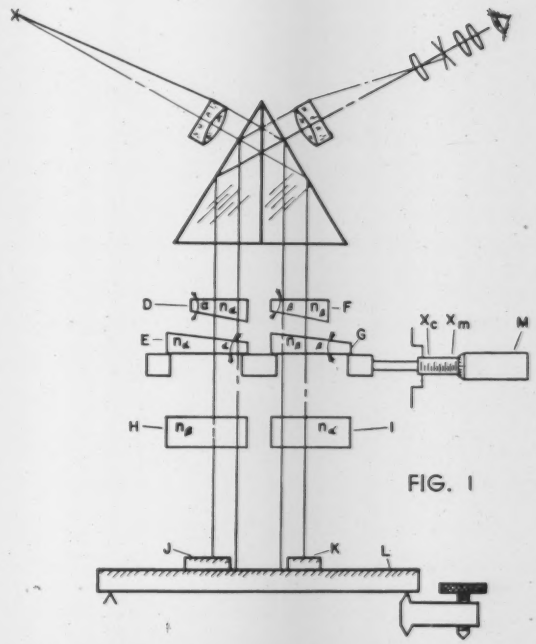

FIG. 1

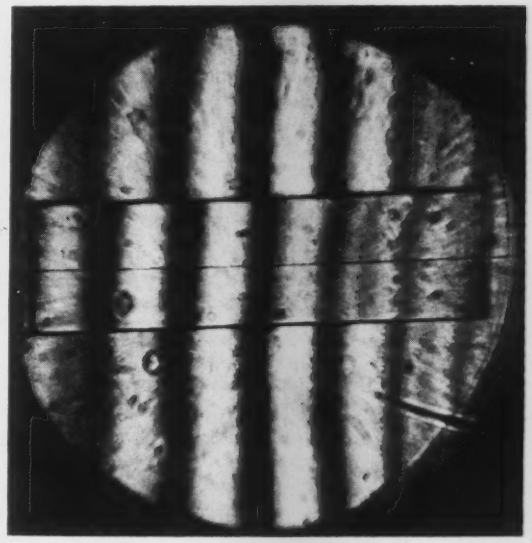

FIG. 2

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CAVITATION IN CONTROL VALVES

G. F. STILES
Fisher Governor Company

No known material can withstand cavitation erosion, which starts at critical pressure differential. Here is how to design out the risk of cavitation.

CAVITATION—the formation of a cavity or vacuum in a flowing stream—is a potential problem to all who design or use hydraulic equipment. This phenomenon can occur in all types of liquids and over wide ranges of pressure and temperature. The evidences that cavitation is occurring in hydraulic equipment include noise, vibration, loss of power and efficiency, and physical damage.

Records on cavitation date back more than 200 years. In 1754 Leonhard Euler, the brilliant Swiss mathematician (well known to engineering students for his derivation of formulas on column loading) published a work on the theory of hydraulic turbines. In that work Euler noted that a discrepancy between theoretical and experimental results was evidenced when an insufficient pressure existed in a liquid.[1] In 1907 an article described the failure of Francis-turbine runners after only a few weeks of operation.[2]

Cavitation and its problems have been the subject of extensive research for many years. Both the U.S. and British navies have conducted many tests on the effect of cavitation on the life expectancy and performance of ships' propellers. Of particular significance is the great amount of cavitation research which has been done by and for the pump industry. As a result, most pump manufacturers now can furnish their customers with the net positive-suction-head require-

December Meeting—Thursday, Dec. 21, 1961

Place—Rio Hondo Country Club, 10627 S. Old River School Road, Downey, Calif.

Subject—Control Philosophy for Nuclear Reactors, by R. L. Detterman, Atomics Int'l., North American Aviation, Inc.

Maintenance Methods—Electronic Potentiometer Trouble-shooting, by Wm. Edmonds, Minneapolis-Honeywell Regulator Company.

ments to insure that a given pump operating under a given set of conditions will not cavitate. Unfortunately, the same type of statement cannot be made about the control-valve industry. To date, little research specifically involving cavitation in control valves has been reported.

The Cavitation Mechanism

The *theoretical* tensile strengths of ideal liquids should be of the order of tens or even hundreds of thousands of pounds per square inch,[3] and cavitation should be unknown, theoretically. However, real liquids do not show strengths even approaching this magnitude. Most liquids are observed to form voids or cavities when subjected to tensions approximately equal to their vapor pressures (which depend on the type of liquid as well as its temperature).

Cavitation is a two-stage phenomenon. The first stage involves the formation of vapor bubbles, similar to the change of state that occurs in a hot liquid that is flashing (i. e. changing to vapor) as the result of a pressure reduction. If the process could be stopped here there would be no more problems in control valves than those encountered when handling flashing liquids. Unfortunately, once these voids or cavities have been formed and become filled with liquid vapor, it often is impossible to keep the process from going to completion, through the second stage.

The second stage of the cavitation process is the collapse or implosion of the vapor bubbles formed in the first stage. It is these implosions which produce the evidences of cavitation (noise, vibration and material damage).

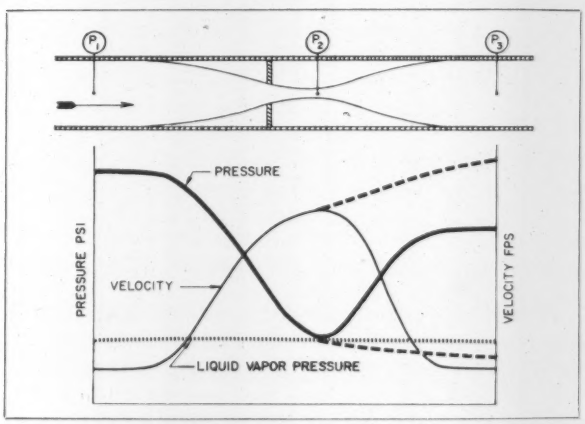

FIG. 1. PRESSURE AND VELOCITY plotted for points along the flow stream through an orifice.

Flow Analogy

Fig. 1 shows a pipe with an orifice, which can be considered analogous to a control valve, the pipe section corresponding to a valve body and the flat-plate orifice corresponding to a valve plug—except, of course, that the orifice area could be varied with the valve plug.

The Bernoulli theorem states that the total energy level of a system must remain constant at every point in the system (assuming no energy is lost through the boundaries of the system in the form of heat or work). The Bernoulli equation in terms of feet of head for the system in Fig. 1 (ignoring the elevation factor) is:

$$\frac{P_1}{W}+\frac{V_1^2}{2g}=\frac{P_2}{W}+\frac{V_2^2}{2g}+H_{L(1\text{-}2)}=\frac{P_3}{W}+\frac{V_3^2}{2g}+H_{L(1\text{-}3)}$$

where P = pressure, in psf; W = specific weight of liquid, in lb/ft^3; V = velocity, in ft/sec; g = acceleration of gravity, 32.2 ft/sec^2; H_L = friction head loss, in ft.

If it is assumed that the friction head loss in the fluid-stream contraction between points 1 and 2 can be neglected, the total head at each of these points consists of the sum of the static and velocity (kinetic) heads:

$$\frac{P_1}{W}+\frac{V_1^2}{2g}=\frac{P_2}{W}+\frac{V_2^2}{2g}$$

In order for a given quantity of liquid to pass through the restricted area of the orifice, the velocity of the fluid stream must increase. As the velocity increases, an interchange of energy takes place between the static and velocity heads, and pressure decreases. If this increase in velocity is carried far enough, the pressure at the vena contracta (point of minimum cross section) reduces to the vapor pressure of the liquid. At this point, voids or cavities can appear in the fluid stream, resulting in the first stage in cavitation (formation of vapor bubbles).

As the fluid moves downstream it expands from the vena contracta into the large pipe area, with a resultant decrease in velocity. This deceleration of the fluid results in a reversal of the energy interchange—that is, the static (pressure) head recovers some of the energy which it had previously lost. If the downstream pressure is being maintained at a point above the vapor pressure of the liquid, the vapor cavities are forced to collapse, or implode; when this happens the second and final stage of the cavitation phenomenon results.

The Bernoulli equation can be written between points 1 and 3, using the assumption that the flow areas are equal—the kinetic-energy terms will be equal and cancel each other. Leaving out the head-loss term would indicate that P_1 was equal to P_3; this is clearly wrong as it contradicts experimental data. It is no longer possible to equate the sum of the static and kinetic heads. Therefore, the head-loss term for the downstream station must be included:

$$\frac{P_1}{W}+\frac{V_1^2}{2g}=\frac{P_3}{W}+\frac{V_3^2}{2g}+H_{L(1\text{-}3)}$$

Some portion of the pressure energy has been converted to some other form. That form is heat, and is due to fluid friction both at the boundaries of the system and in the contraction and subsequent expansion of the fluid stream. Most authors of texts on fluid mechanics agree that an appreciably greater friction head loss occurs in the expansion of a liquid stream than occurs in a contraction.

The dotted lines in Fig. 1 show that the pressure at point 3 could have been maintained at a value equal to, or less than, the vapor pressure of the liquid. Then the pressure could not recover sufficiently to cause

the vapor cavities to implode. A two-phase mixture of liquid and vapor bubbles would continue downstream. The control valve would not be cavitating, but would be simply passing a flashing liquid.

The foregoing suggests two solutions to the cavitation problem—either (1) prevent the formation of cavities, or (2) prevent their collapse.

Cavitation Damage Mechanism

There are several theories as to the actual mechanism by which cavitation inflicts physical damage to the solid surfaces it contacts. Regardless of the damage mechanism, the destruction always occurs in the area where the implosions are taking place. Pressures of the magnitude of 100,000 psi have been reported in the collapsing cavities.

Two of the more-prevalent theories regarding the mechanism of damage will be discussed briefly. Both make use of the high pressures generated when the vapor bubbles collapse.

The theory which is the most popular, and certainly the simplest, says that the damage is caused by extremely-high-pressure shock waves striking the solid surfaces of a system boundary. These shock pressure waves are produced by the imploding bubbles and act as tiny hammer blows on the surfaces. Presumably only those imploding bubbles close to the solid surfaces are capable of producing damage, the energy of bubbles which implode well into the fluid stream being absorbed by the fluid itself. Repeated blows tend to fatigue the surface until eventually a tiny piece of metal is torn away, and the process repeats.

Support is given to this theory by the fact that some of the harder materials can be subjected to known cavitating conditions for extended periods of time with no visible evidence of damage. The reason advanced for this is that the stress applied by the implosion does not exceed the yield point of the material and, consequently, considerable time is required to fatigue the surface metal.

With some softer materials, such as commercially-pure aluminum, no time lapse is required. A microscopic inspection of the surfaces made after only a few seconds exposure to cavitation will show individual indentations in the aluminum, indicating that the magnitude of the implosion stress has been greater than the yield point of the material. When the indentations overlap, it is easily seen why aluminum, which work hardens rapidly, is subject to rapid deterioration.

The other theory,[4] while acknowledging that the high-pressure shock wave is a mechanism of damage, attributes at least part of the destruction to a chemical attack. As an implosion occurs on a solid surface, the surface is forced to absorb work. In doing so, the surface on which the work was done experiences a localized rise in temperature. This temperature increase may be sufficient to permit a vigorous (though transient and short-lived) reaction between the water and metal, forming an oxide film on the metal. Secondary effects, which might result when subsequent blows fall on the same surface, include breaking up and washing away the brittle oxide film, thus exposing new base metal to attack.

FIG. 2. CAVITATION EROSION
and failure of a valve plug

Regardless of the mechanism by which cavitation does its damage, the damage can be severe. Fig. 2 shows a valve plug which was subject to severe cavitation for only a few hours. The tip material is solid Stellite; the upper portion is 18-8 stainless steel overlaid with Stellite.

Velocity Influence

Studies made of cavitation damage rates have indicated that the frequency with which a given surface is struck by implosions is relatively constant as long as liquid velocity remains constant. It has been shown that this impact frequency increases rapidly with velocity. Several series of tests, conducted independently of each other, verify that the impact frequency increases with at least the 6th power of velocity.[5]

In a control valve, liquid velocity through a valve port depends on the pressure differential which exists

between the inlet and the vena contracta. The relationship between the two may be ideally expressed by the well-known formula:

$$V = \sqrt{2gh}$$

By converting the head term into pressure units, and evaluating the known constants for ambient-temperature water flow, the following relationship exists:

$$V = 12.2\sqrt{P_1 - P_2}$$

where V = velocity, in ft/sec; g = acceleration of gravity, 32.2 ft/sec^2; h = head of flowing liquid, in ft; P_1 = valve port inlet pressure, in psia; P_2 = vena contracta pressure, in psia.

This shows that velocity varies as the square root of the pressure drop.

Assume a control valve has a pressure differential of 400 psi and cavitation is occurring. If the pressure differential is increased by a factor of 4, up to 1600 psi, the velocity will increase by a factor of $\sqrt{4}$, or 2. Then, because the damage rate varies as the 6th power of the velocity, 64 times (2^6) as much damage could be expected for $\Delta P = 1600$, as for $\Delta P = 400$.

Cavitation has been a problem in the control-valve industry for many years, but is becoming more and more serious as flow temperatures and pressures increase. In the past, materials were selected which could withstand its attack. However, research and field experience have shown that no known material can remain undamaged indefinitely under severe cavitating conditions. Some of the harder steel alloys, and the hard surfacing materials in common use today, have materially lengthened useful life expectancies of control valve components.

In view of the increasing severity of the problem it is now believed that the only logical approach lies

in developing a system where cavitation is eliminated. Accordingly, a study program has been instituted to determine the limits of inlet pressure and pressure differential which may be imposed on control valves before cavitation is experienced. The ultimate goal of this research program is to gain the knowledge necessary to produce a valve or a system of valves which will be capable of indefinite service without cavitation damage.

Critical Flow

When a control valve is subjected to a constant inlet pressure, but to increasing pressure differentials, an apparent critical pressure differential is reached. Increasing the valve body pressure differential (ΔP) beyond this point results in a flow rate that is no longer proportional to $\sqrt{\Delta P}$, and the inception of noise and vibration. This may be the point where cavitation begins. The velocity increase may reduce the static pressure to the liquid vapor pressure at the vena contracta. Possibly no subsequent decrease in outlet pressure can be realized until all the liquid has vaporized.

In the tests where this has been observed, valve inlet pressures have been measured approximately one pipe-diameter upstream, and the outlet pressure approximately six pipe-diameters downstream from the control valve (in accordance with accepted testing procedures). However, in all the test work done up to this point, no cavitation damage has been observed.

Several reasons for this may be advanced;

1. The tests were of short duration—just long enough to obtain the necessary data readings.
2. The components were usually fabricated of relatively hard materials.
3. The tests were conducted at relatively low inlet pressures.

Current Research

Several basic decisions were necessary before the current research program was started. First, a material had to be selected from which to manufacture the required valve plugs and orifices. Second, a particular style and size of valve plug had to be chosen for use during at least the initial stages of the work.

The material selected had to be soft enough to be a good indicator of early cavitation and yet sturdy enough to withstand the treatment necessary for use as a valve plug. It also had to exhibit at least fair machinability so that surface finishes could be maintained from sample to sample. Several researchers had made use of commercially-pure aluminum with good success. It was decided to use this material.

In selecting a valve plug style and size, one requirement was that its rated capacity conform closely to that of the existing laboratory pumping system in order that uninterrupted long-duration tests could be conducted. Also, it had to be possible to manufacture the valve plug to close tolerances so that exact reproductions could be produced. The valve plug chosen was a ¼″-diameter percentage-type contour plug, which was machined using a template. This plug was adopted for use in a 2″, 1500-psi, globe-style body.

The first step in the testing program was to obtain capacity curves (i.e., flow rate vs $\sqrt{\Delta P}$ with valve lift held constant). All of the tests were performed using ambient-temperature water as the flowing medium. At this point in the program it was desired that no cavitation damage be done to the valve plug machined from Type-316 stainless steel rather than aluminum. Capacity curves were obtained for both flow-opens and flow-closes directions of flow, at inlet pressures of 500, 1000, 1500, and 2000 psig, and at three different valve lifts, ranging from just off the seat to full rated lift. The purpose in gathering this data was to determine the critical pressure differentials which existed for the various conditions listed. Up to the critical point, the flow rate is proportional to the $\sqrt{\Delta P}$ and often is expressed as:

$$Q = C_v \sqrt{\Delta P}$$

where Q = water flow rate, in gpm; C_v = an experimentally-determined flow coefficient; ΔP = pressure differential existing across valve body, in psi.

Plotting such an equation on rectangular-coordinate paper should produce a straight line, as long as the proportionality holds—as long as C_v remains constant. The critical pressure differential then is defined by the point at which the plot deviates from a straight line (Fig. 3).

Plotting the data indicated that the critical pressure drop varied markedly with flow direction and, to a lesser degree, with both inlet pressure and valve lift. A dimensionless factor (K_c) called the index of incipient cavitation was formulated to describe this critical point. K_c is defined as follows:

$$K_c = \frac{P_1 - P_2}{P_1 - P_v} = \frac{\Delta P_{(max.)}}{P_1 - P_v}$$

where $\Delta P_{(max)}$ = maximum pressure differential, in psi, which may be taken across the control valve before cavitation begins; P_1 = inlet pressure, in psia; P_2 = outlet pressure, in psia; P_v = vapor pressure of flowing liquid, in psia.

If P_2 is less than P_v this formula will not apply because the liquid will vaporize but will not return to liquid.

Step two in the program was to determine whether or not the critical point (as obtained from the capacity curves, and as defined by the cavitation index K_c) was in reality a valid indication of when cavitation damage would initially be encountered. These tests were performed using the commercially-pure aluminum valve plugs and orifices. The following procedure was followed in combining various values of flow direction, inlet pressure and valve travel:

1. Locate the break-off or critical ΔP from the capacity curve.
2. Beginning at a ΔP below critical, maintain flow through the valve for a period of ten minutes (previous preliminary tests had indicated that a ten-minute test period would be sufficient to detect pitting if cavitating conditions existed).

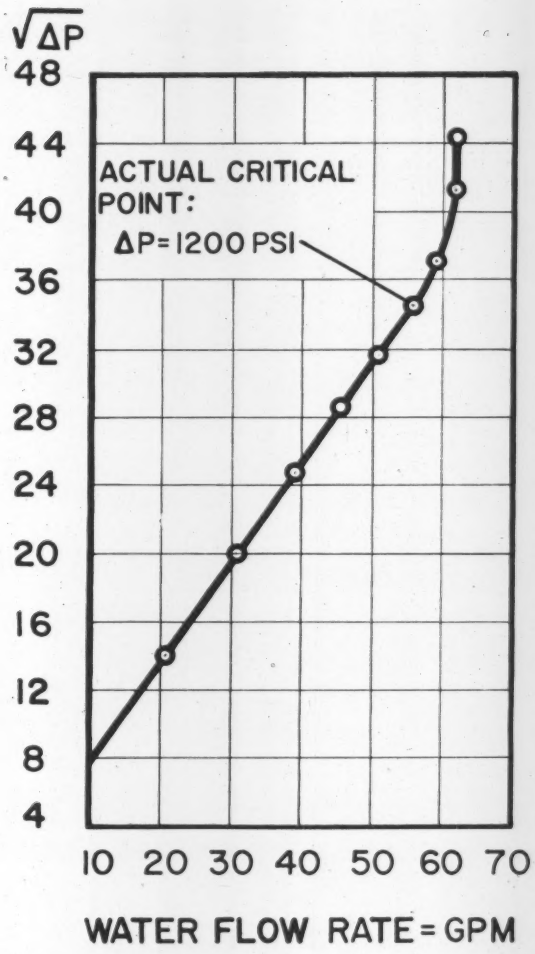

FIG. 3. TYPICAL valve flow curve, showing critical point.

3. Remove valve plug and orifice from body and inspect for evidence of pitting.
4. If no damage was evident, repeat steps 2 and 3, increasing the ΔP each time until damage to either the plug or orifice was evident.

Comparison of the results of the capacity and damage tests confirmed the suspicion that a relationship existed between the break in the capacity curve and the inception of cavitation in a control valve. The lowest pressure-differential at which damage was noted coincided closely with the first hint of deviation from linearity in the capacity curve. Thus it can be seen that the capacity curve is actually a sensitive indicator of the inception of cavitation in a control valve. Further testing can be simplified because now it should not be necessary to perform damage tests.

Capacity and damage tests also were performed on ¼"-dia port-guided percentage plugs, as well as on several other types. The results obtained verified the previous tests.

Test results obtained during this program, as well as results derived from capacity tests performed independently of this program, indicate a wide variation in allowable K_c values between the flow-opens and flow-closes directions of flow. Generally speaking, contour valve plugs installed in the flow-opens direction of flow in either globe or angle bodies will exhibit a K_c value of approximately 0.65. The same valve plugs installed in the same bodies, but in a flow-closes direction of flow, will show K_c values of about 0.20. These values indicate the advisability of a flow-opens direction of flow whenever possible. Although all of the test work performed specifically for this program was done using ambient-temperature water as the flowing medium, the validity of the K_c formula as a means of predicting cavitating conditions in a control valve has been verified for water at much higher temperatures.

With the appropriate value of K_c known, the limiting pressure differential can be obtained simply by the equation:

$$\Delta P_{(max.)} = K_c (P_1 - P_v)$$

The solution of this equation will always yield a value of $\Delta P_{(max)}$ regardless of the magnitude of the inlet pressure. Practical experience has confirmed, however, that in a globe body ordinarily little cavitation damage is experienced when the pressure differential is less than 500 psi. Laboratory test results, using water at normal ambient temperatures, indicate that a value of 400 psi would be more realistic. Therefore, it has been recommended that this 400 psi be used as the limiting value of a pressure differential, or an inlet pressure in case of a full drop, unless the solution to the equation involving K_c decrees that a greater value may be used.

The effectiveness by which cavitation damage can be predicted using the K_c formula was tested by installing bodies in series. Either two or three 1" single-ported globe bodies installed in the flow-opens direction and equipped with soft aluminum orifices and linear plug valves were used for this test. By varying K_c values and setting the pressures accordingly through valve-lift manipulation, it was possible to either obtain damage or not in accordance with the previous test results. These tests were conducted with inlet pressures up to 2000 psig.

Damage Location

Location of cavitation damage to control-valve plugs and orifices depends to a great extent on the direction of flow through the body as well as the pressure differential across it. When the body is installed in a flow-opens direction, damage almost always occurs to the plug and occasionally to the orifice. The reverse is generally true when flow tends to close the plug.

Fig. 4 shows six sample plugs used in the damage tests. Each of these plugs was tested in a flow-opens direction for a period of ten minutes at an inlet pressure of 2000 psig and at full rated travel. The one distinguishing difference between them was in the pressure differential. Table 1 lists the pressure differential used with each plug.

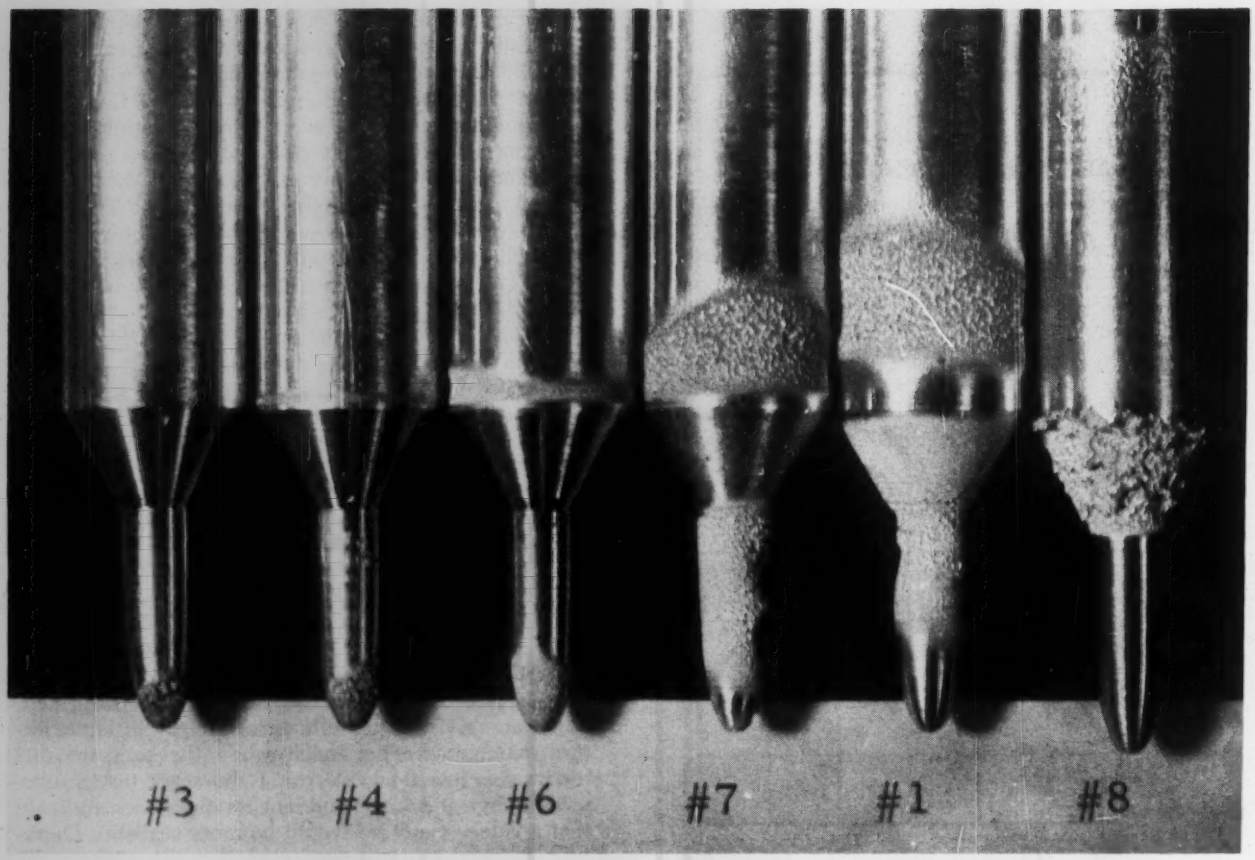

FIG. 4. DAMAGED test plugs subjected to different pressure differentials (Table 1).

Table 1—Pressure Differential across Valve.

Sample	ΔP (psi)
3	1300
4	1400
6	1600
7	1800
1	1900
8	2000

Table 2—Static Pressure at Inlet and Outlet.

Sample	Inlet Pressure (psig)	Outlet Pressure (psig)
16	500	25
18	1000	50
17	1500	70
1	2000	100

The damage seen on Sample #3 was the initial damage obtained for the conditions listed above. At pressure differentials below 1300 psi, no trace of damage could be found. Note that, beginning with Sample #4, there are two zones of damage on each plug. The damage which appears first on the very tip of the contour is seen to progress up the contour and thence onto the beveled area as the pressure drop is increased. This damage is due to cavitation occurring at the point of minimum flow area between the plug and the orifice. With each succeeding increase in pressure differential more water flows through the orifice. Therefore, the velocity of the stream is greater also. This, coupled with the decreasing back pressure, explains why the damaged areas tend to move farther and farther downstream. Note also the damaged areas which begin to appear with Sample #4 on the cylindrical guide portions of the plugs. This reveals how abrupt changes in cross section can cause localized cavitation.

Fig. 5 shows variation in damage with inlet pressure. Here outlet pressure was adjusted to give the maximum noise from the valve. Flow direction, test time and valve travel were the same as for the preceding illustration. Test conditions for the samples shown in Fig. 5 are given in Table 2.

Considerable experimental information exists regarding the relative resistance of a number of metals to the attack of cavitation. However, the bulk of this information has been obtained using a technique which does not simulate the conditions which exist in a control valve. In an attempt to determine relative resistance to cavitation damage under flowing conditions, a series of tests was conducted on a number of valve plugs machined from metals that are commonly used as body and trim materials in control valves. These plugs were then installed in a 2″, 1500-lb, globe-style body in the flow-opens direction and subjected to an inlet pressure of 2000 psig and a full drop. The time required to produce equal damage on the various samples was recorded.

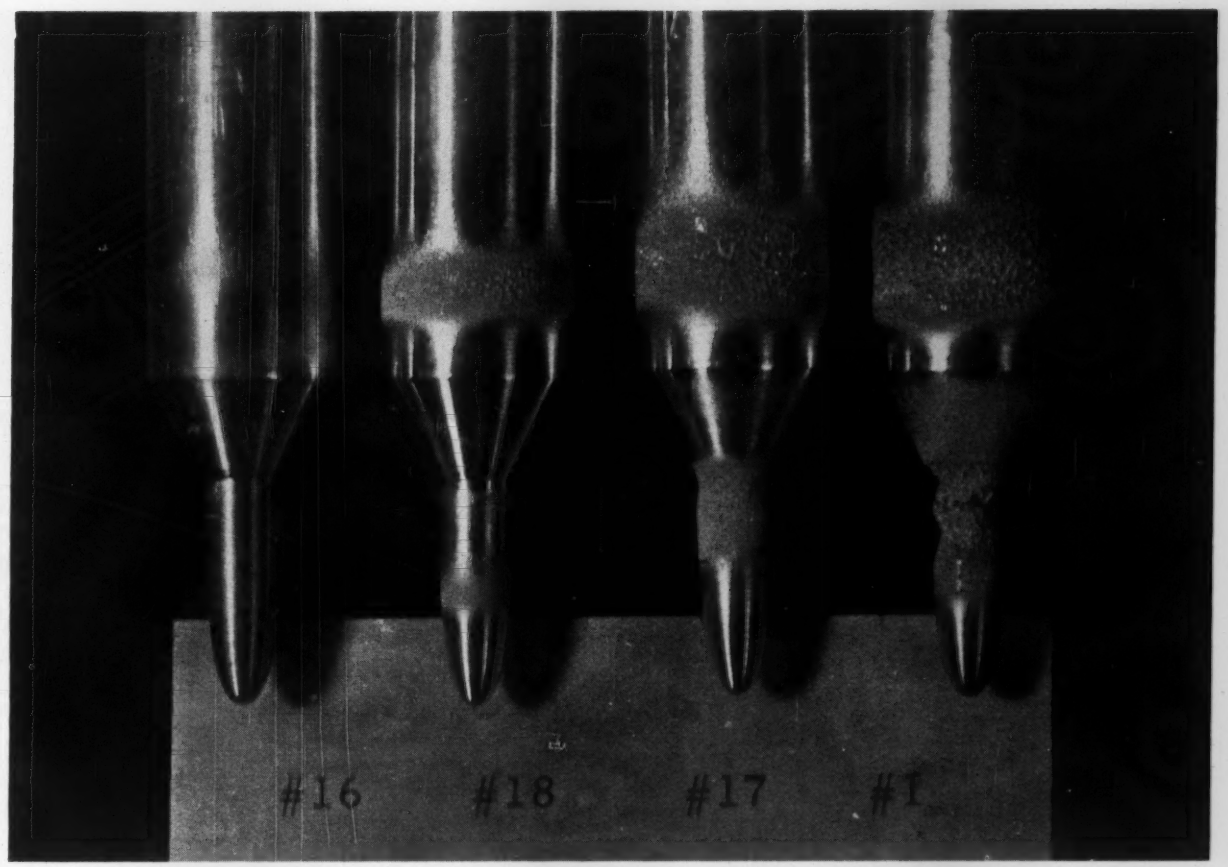

FIG. 5. EFFECT of varying inlet pressure (Table 2).

Table 3 lists the results of these tests. Type 316 stainless steel was arbitrarily assigned a value of 1.0, because it is considered a standard trim material.

Table 3
Index of Resistance to Cavitation Damage

Material	Hours Tested	Index
#6 Stellite over Type 316 SS	120	>20*
Stainless Steel—17-4 PH	12	> 2*
Hardened to 45 RC		1.33
SS Type 316 Electrolized	8	
Stainless Steel—Type 316	6	1.00
Cast Iron—A126 Class C	4.5	0.75
Chrome Moly Steel—C5	4.0	0.67
Nodular Iron—A395	2.5	0.42
Carbon Steel—WCB	2.25	0.38
Carbon Steel—AISI C1213	1.0	0.17
Brass—ASTM B16	0.5	0.08
Aluminum—1100-F	(2 min)	0.006

*Indicates that the damage was less than that of Type 316 SS when the test was discontinued.

Values in the table greater than 1.0 indicate a resistance to cavitation damage superior to that of Type 316; values less than 1.0 indicate the reverse. No great degree of accuracy is claimed for the values listed; however, it is believed that they do serve to indicate the approximate relationship between the metals. In the future other materials will be added to this list.

Conclusions

When it is known that cavitation will be a problem, present practice is to specify valves in series. The number of valves required in series depends on the total pressure drop which must be handled, and is determined by the use of the K_c formula discussed earlier. Standard valves and actuators are used in such a series.

The following conclusions have been drawn as a result of this test program:

1. Proper choice of materials will extend the service life of control-valve components.
2. No known materials are available which will withstand the severe cavitating conditions often encountered today.
3. When severe cavitation is expected, the pressure-control methods developed during this program can be used to avoid the onset of cavitation.

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4. W. H. Wheeler, "Identation of Metals by Cavitation," ASME Paper No. 59-Hyd-15.
5. Knapp, "Accelerated Field Tests of Cavitation Intensity," ASME Paper No. 56-A57.

RECALIBRATIONS

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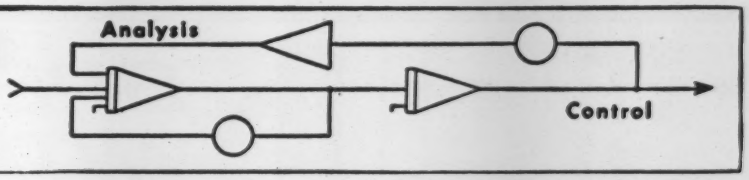

Newsletter

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Bits

Under **PIECES** we have:

Panel discussion on "The Future of Analog Computation"—Western S/C Meeting of 12 May, 1961, Ambassador Hotel, Los Angeles.

Also report on the Western S/C Meeting of 14 Sept., 1961, including papers on Use of Computers and Analog Simulation at Autonetics, by the following men from Autonetics —**HAROLD EHLERS, DICK BLOSSER, R. G. KINKADE** and **A. C. POFF, JR.**

Announcements received

Eastern Simulation Council

18 September 1961; At Reeves Instrument Company, New York City, on "Analog Multipliers."

"Review of the Use of Analog Multipliers", Arthur Rubin (EAI)
"Some Special Multiplier Applications", Richard Howell (Reeves Instrument and Project Cyclone)
"Special Techniques for Multiplication and Other Functions", Joe Nelson (Computer Systems)
"A New Servo Multiplier", Bernard Loveman (Reeves Instrument and Project Cyclone)

Tour of Project Cyclone.

Southeastern Simulation Council

20 October 1961; At The Martin Company, Orlando, Florida

"Summary of Maintenance Procedures at Martin-Denver", A. A. Barkauskas (Martin-Denver)
"Generalized Two-Dimensional Power Trajectory Simulation", John Stricker (Martin-Baltimore)
"A Seven-Degrees-of-Freedom Missile Simulation", Maynard Sikes (Martin-Orlando)
"A Digital Expansion System for Analog Computers", T. D. Truitt (Electronic Associates)

Tour of the Martin-Orlando Facility

Pieces

WESTERN S/C MEETING OF 12 MAY ON "THE FUTURE OF ANALOG COMPUTATION"

On May 12th more than a hundred people, representing 62 organizations (a record?), signed the register at the Western Simulation Council's meeting, which was held at the Ambassador Hotel in Los Angeles following the 1961 Western Joint Computer Conference.

The following writeup is based on a report furnished by **F. C. Rieman** (Space Technology Laboratories, Los Angeles 45, Calif.), and on notes taken by your Sec'y.

"The Future of Analog Computation" was the subject discussed by a panel of qualified experts. **George Bekey** (Space Technology Labs) acted as moderator for the group, which included:

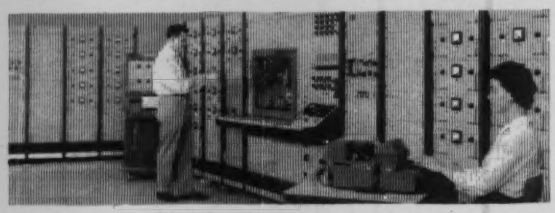
William Comley (Douglas Aircraft, El Segundo, Calif.)
Harold Ehlers (Autonetics, Anaheim, Calif.)
Robert Horwitz (General Dynamics/Astronautics, San Diego, Calif.)
Robert Howe (University of Michigan, Ann Arbor, Mich.)
William McLean (North American Aviation, Los Angeles, Calif.)
Rajko Tomovic (Boris Kidric Institute, Belgrade, Yugoslavia)
Milton Warshawsky (Wright-Patterson Air Force Base, Ohio)

Hans Meissinger (Chairman of the WSC) introduced the members of the panel, whose organization he credited to **Lad Kovach,** and went on to say that he believed analog people are challenged today as they have not been for the past decade.* It is, said Hans, essential to show the public that we are alive, can produce creative ideas, and provide leadership to keep analog computation with us. He said he believes the analogs are here to stay, but in what form? They must show creative and imaginative growth; there is particular need for stepped-up communication, including publication.

Bill Comley deplored the growth in application of digital techniques to analog problems. The relative position of analog in the future will, he believes, depend on new applications such as data reduction and data gathering, real-time operation, repetitive mode of operation, automatic programming, and the use of small special-purpose analog computers.

Harold Ehlers stated that it is easier to perform linear analyses with digital than with analog equipment; however, when programs require simulation of hardware, then emphasis shifts to the analog. In many applications where the mathematical model of the hardware is too difficult to obtain, combined simulation of hardware and analog is desirable. He

*Ten years ago, who would there have been to challenge *what?*—Ed.

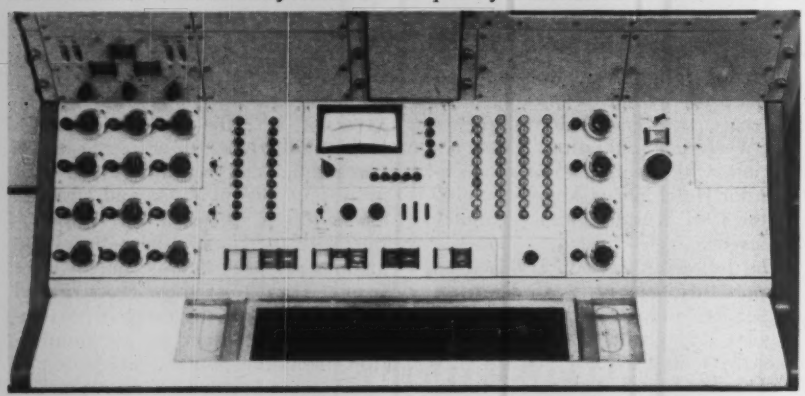


SPEAKING WITH EASE®

An up-to-the-minute report on computer technology

NEW *OPERATOR DESIGNED* CONTROLS OFFER UNIQUE FEATURES

The poor computer operator is getting swamped. Fighting his way through bundles of patchcords, poking around inside cabinets to find fuses, surrounded by a hundred knobs and buttons. His future only becomes more bleak as problems increase in complexity. To counteract this trend, EASE® engineers have come up with a new control idea . . . if not revolutionary, then highly practical. In short, they have created a control system for the new EASE 2100 series computers that is "operator designed."



A typical control center for a 2100 series computer, showing pinboard in foreground.

Fingertip Programming

From an operator standpoint, what is the most logical and practical approach to computer controls? *Centralization* . . . the prime feature of the new EASE control system. It means the operator can change the problem or vary parameters by controls which are within arm's reach. If the computer is capable of iterative operation, this is particularly important since certain types of iterative problems start with many unknowns and involve "homing in."

The most significant feature in the centralized control area is the pinboard. Located right in the shelf at the main control center, it incorporates all those controls originally found on the patchboard, as well as added controls, too. To make a connection, all the operator does is insert a pin. This completes a circuit which formerly required two holes on the patchboard. Programming the pinboard can take place either on or off the computer. Or to make it really simple, paper overlays can be programmed in pencil, then put right over the pinboard where the pins are quickly inserted.

Automatic Error Indicators

The "operator designed" controls also include a number of improved programming checks. The first is a *non-valid address lamp* that lights whenever the operator punches an address that does not exist in the computer. An *operator error lamp* tells him when he has made a mistake in programming, while the *DO/IT error indicator* lights when an error is made on the automatic control system. The *DO/IT error indicator* can also be programmed into the audible alarm, of which we'll speak in a moment.

Faster Checkout

Checkout, an operation that always takes up too much time, is relieved of much tedium through these new controls. The pinboard, for example, has no tangled wires to trace out. *No matter how complex the problem, it is always easy to read.*

An even more dramatic checkout feature is the audible alarm. This alarm replaces the warning buzzer and is controllable in volume, pitch, and modulation. Used previously just for overload warnings, it can now be programmed on the pinboard to monitor overload, iterative time base failure, servo set pot error, fuse failure, and manual pot alarm. To illustrate its advantages—when setting servo pots, the operator does not have to look at the meter. He just listens. If he hears the alarm, panel lights will pinpoint the error exactly.

Expansion Feature for Iterative Operation

The flexible design of the new centralized control console allows easy conversion of a standard analog computer to an iterative analog computer. To make the conversion, one simply adds the Iterative Differential Analyzer Control plug-in module and transfer module—*using existing connections*. All the other controls necessary for iterative operation are already built into the standard computer.

"Operator designed" controls—of which this report has only given examples—is one of many important features of the remarkable new 2100 series computer. Other features will be discussed in future editions of SPEAKING WITH EASE.

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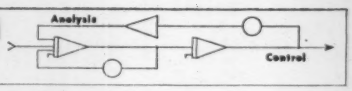

described other applications in which analog equipment is used at Autonetics, such as combined analog/digital simulation, checkout of engineering systems, and specific applications in submarine and hydrofoil control. Areas in which he felt the analog manufacturers should strive for improvement included reliability, especially in multipliers and function generators; greater bandwidth; higher accuracy; and better setup procedure.

Bob Horwitz cited economics and communication as reasons for the contrast between analog and digital computers. The ratio of digital to analog advertising is about 100 to 1 and, naturally, industry feels this pressure from the digital manufacturers. Also, analog capabilities have been static for the past five years, largely because of failure to distribute information on analog techniques. To improve the outlook for analogs in the future, Bob said he thought the analog people should seriously consider going into the business of thinking machines.

Bob Howe outlined the educational benefits gained in schools where analog computers are used. First, the student is introduced the use of the analog computer as a tool for solution of engineering problems. Second, he becomes familiar with the actual physical system and the significance of individual terms during the programming of his problem. Third, he gains a deeper insight into the behavior of dynamic systems.

As to the future of analog computation in universities, Dr. Howe said that this will depend largely on economics. He believes the analog computers should be relatively small (20 amp) with increased flexibility and capabilities. Greater ease in programming and operation should be incorporated into these small computers so that the student's time can be more evenly distributed between programming and operation.

Bill McLean said he considered it an undesirable characteristic of analog computers that the hardware is much more complicated than that in digital machines. Other reasons which he gave for the downward trend* in use of the analog were lack of reliability, cross-talk, drift, lack of accuracy, and present overload systems. He implied that if computation requires greater precision and performance, then digital systems will be the engineer's tool. Bill said he believed that during the next five years the analog computer will be relegated to the field of education and repetitive computation (if this is necessary).

Dr. Tomovic, speaking from the European point of view, stated his belief that the analog has a bright future because of improved mathematical methods. Analog applications which he enumerated included error analysis, adaptive control systems, correlation functions, and probability distribution. He suggested that the greatest industrial and educational need might be for small rep-op computers with non-linear components.

Milt Warshawsky said he agreed that the analog computer does seem to be dying. However, the fact remains that the analog is definitely superior to the digital in certain fields.

Milt challenged the statement that digitals are riding high because of their accuracy: they are merely *precise.*

He went on to say that less than 1% of the engineers and scientists at Wright Field supply the work for their analog installation. This keeps the installation comfortably busy, but during the same period the digital facility has expanded tremendously. Yet the problems at Wright Field are essentially analog!

*Only apparent if you are riding the digital bandwagon.—Ed.

Milt believes that this state of affairs is caused by the tremendous efforts put forth by IBM, Remington-Rand, and others in propagandizing the general public* as well as those with whom we are more concerned—the scientists and engineers.

In an attempt to reverse this trend Milt has organized an educational program. Electronic Associates contributed 2 instructors, and 60 rather high-level people at Wright Field took the course, which required that they be off the job for one week. The results, measured by questionnaires administered on a before-and-after basis, were so good that Milt's group now has the go-ahead to educate everyone who might be concerned at Wright Field as to the usefulness of analog techniques and computers.**

In conclusion, it seemed to be the belief of the panelists, as well as those in the audience who participated in the discussion—which was spirited, to say the least—that analog computers will continue to play an important role in science and engineering, provided: **That strenuous efforts are put forth by manufacturers and users (both in industry and the universities***) to seek new applications; to develop new techniques and more reliable equipment; and to improve channels of communication, not only among analog users but with the general public as well.**

*Maughan Mason, quotes a guide showing visitors around Thiokol Corporation's Brigham City Plant as saying: "This is the IBM analog computer."

**Which moved Bob Howe to quip: "Milt, you're biased—but you're biased by the facts!"

***It was pointed out that some attempt should be made to educate high-school students on the application of analog computers. Milt Aronson, in Pittsburgh, Pa., is attempting an experiment at the high-school level this year. We will report it in detail later. —Ed.

WESTERN S/C MEETING OF 14 SEPT. ON USE OF COMPUTERS AT AUTONETICS

On July 13th the Western Simulation Council held a meeting, at the Space Technology Laboratories in Los Angeles, on which we have no info as yet. However, **Bill McLean** (North American Aviation, Los Angeles, Calif.) has broken some kind of record by getting three out of the four papers presented at the September 14th meeting to us in time for this November issue of the *Newsletter.*

About 60 people traveled to Anaheim* to visit the new Autonetics—

*Wonder how many went to Disneyland as well as, and how many instead of, the Simulation Council meeting!—Ed.

La Palma facility and participate in discussions of their work.

Ehlers on Solution of Engineering Problems

Harold Ehlers (Autonetics) led off with a talk on "The Use of Computers in the Armament and Flight Control Division of Autonetics for the Solution of Engineering Problems."

He explained that the Armament and Flight Control Division is concerned with the development and manufacture of airborne radar and flight-control systems. The company is hardware-oriented, and the research performed generally has a specific item of hardware as its objective.

The NASAAR radar, which is used in the Lockheed F-104, Republic F-105, and NAA A3J airplanes is a monopulse radar used for air-to-air intercept, air-to-ground bombing, and low-level penetration functions. Flight-control systems are in various phases of development for the A-3J and B-70 airplanes and for the GAM-77 Hound Dog and Minuteman Missiles. Other flight control systems which have been flight-tested include automatic landing systems for aircraft, and stabilization systems for helicopters. Flight control research has been carried out for the control of space vehicles, hydrofoil boats, submarines and VTOL vehicles.

The Armament and Flight Control facilities include 12 consoles of Electronic Associates analog computing equipment, a Bendix G-15 general-purpose digital computer which is joined to the analog equipment by a Packard-Bell Multiverter, and two Autonetics Recomp II digital computers. In addition, an IBM 7090 is available for use through NAA's corporate facilities. As the IBM equipment is located in Inglewood, there is a delay of one or two days in the transmission of data.

Most of the digital programs were written within Autonetics; others were obtained from SHARE, the Recomp Users Group, and other North American Aviation divisions.

The programs most frequently used may be divided into four categories:

(1). Worst-Case Circuit Analyses
(2). Error Analyses
(3). Solution of Non-Linear Differential Equations
(4). Linear Servo Loop Analyses

(1) is an analysis of a circuit for what are considered to be severe conditions which might result in circuit failure. The circuit equations are written and solved by the computer for specific boundary conditions, and are used by the reliability section to assure that adequate margins of safety exist in the circuit design. Currently all new circuit designs are checked by this means.

(2). In connection with the armament system product line, computers are developed and manufactured for level flight, dive and dive-toss bombing, air-to-air armament control, and terrain avoidance. For all these the design must be such that with a stated level of probability the final error must be less than a specified amount. To verify this, an error analysis of the computer is performed by taking the partial derivative of the output with respect to each error source. A set of algebraic equations thus is derived which relates the output error to each error source.

(3). The IBM 7090 has not yet been used extensively as a DDA simulator to solve non-linear differential equations, but presents strong possibilities for such use in the future. The capacity of the program is about equal to 2,000 DDA integrators. Its lack of use in this manner seems to be a matter of training personnel in DDA programming, plus the fact that the original program did not provide adequate means for locating programming errors. However, the rewritten program provides adequate printout to locate programming errors.

(4). The solution of linear servo problems using the digital computer is straightforward. The differential equations defining the servo system dynamics are converted to Laplace determinant form. Following the rules for solution of algebraic equations by means of determinants, the transfer function between any two variables is simply the ratio of two determinants. The transfer function is thus obtained by expanding the determinants in the Laplace operator S and solving for the roots of the expanded polynomials.

If a root-locus diagram of the servo loop is desired, the solution can be repeated for various values of loop gain, and the roots of the denominator plotted in the S plane as required by the root-locus-technique equation.

If a frequency response plot of the open loop transfer function is desired, $j\omega$ is substituted for S and the resulting complex number solved for the desired value of frequency. The amplitude and phase of the complex number provide the desired information.

To illustrate the point of his remarks, Hal then described some of their digital programs.

An important part of the cost of servo-loop analyses using the digital computers is the reduction of the data from tabular to diagram format. The Stromberg-Carlson CRT output unit for the 7090 (which has recently become available) should aid significantly by permitting the machine to assist in this data plotting. The gain phase or root-locus diagrams may be plotted on the CRT, and a photograph taken of the display tube.

In answer to the question which must have arisen in the minds of many in his audience, "What is the need for analog computers?," Hal explained that the Armament and Flight Control analog computers are fully utilized at the present time and it is expected that they will remain so for the foreseeable future. Types of problems for the analog computers include:

(1) Missile and airplane trajectories
(2) Hardware tie-in
(3) Pilot tie-in
(4) Rapid optimization of complex non-linear systems

The many non-linearities existing in all aspects of these problems generally result in equations which are time-consuming to program and run on the digital computer. Furthermore, parameter adjustment and system optimization can be carried out more expeditiously on the analog computer. Since the aerodynamic functions as well as the flight control hardware generally are not known precisely, there is no real requirement for precision computation.

Tie-in of flight-control hardware—which must operate in real time, of course—with a general-purpose digital computer has not, to Hal's knowledge, been accomplished in this country. It would require a computer comparable with the 7090, and in real time this could become expensive. Therefore, *simulation with hardware has always been with analog computers.*

Another area in which the analog computer has predominated is *studies which require the human pilot in the loop.* For these studies a cockpit simulator with appropriate controls and displays is connected to an analog computer. Again because of the

DR. R. G. KINKADE addresses Western S/C Meeting, Sept. 21, 1961, Autonetics, Anaheim, Calif.

speed and data-handling capacity, a medium-speed, medium-sized digital computer could not possibly handle the task, while an adequate high-speed, large-memory digital computer is too expensive.

A fourth area in which the analog computer has been extensively used is in *optimizing systems which have numerous non-linearities*, and for which it is difficult to predict performance by analytical means. For example, a radar altimeter was studied and improved, and adaptive control systems have been advantageously tested. The beauty of the analog computer is that the engineer can immediately observe the performance of the system. Errors in concept can be eliminated quickly, and the system design rapidly iterated to a final configuration.

Another engineering problem which appeared to be ideally suited to the analog computer was the *design of a guidance platform to withstand a specified vibration environment*. The dynamics of the platform were represented by a high-order set of differential equations with several saturation points. The platform model within the analog computer was subjected to an input sinewave which varied in frequency from 6 to 320 cps, summed with a second input which extended to 480 cps. The displacement rate and acceleration at various points in the system were observed, and the system designed modified in the course of the tests to satisfy performance requirements.

On the Minuteman project extensive use has been made of *combined analog-digital simulation*. The Bendix G-15 digital computer was used to simulate the sampled-data control system on a slowed-down time scale. More recently, the simulation has relied more on hardware tie-in in which the airborne digital computer and the hydraulic servos were joined with the analog computer for trajectory simulation.

In the armament programs an important aspect of the simulation has been the pilot tie-in, using a cathode-ray-tube display. The analog computer with the cockpit simulator is a basic requirement for most dynamic studies of the air-to-air, air-to-ground and terrain avoidance modes of operation.

Blosser on Autonetics' Simulation Facilities

Harold Ehler's talk was followed by a description of the Autonetics Simulation Facilities by **Dick Blosser,** which gave more details than would probably interest readers of the *Newsletter*. However, a few of his comments may be of interest, even out on context. For instance:

Their original installation of about 10 years ago consisted of about 100 amplifiers of Reeves equipment in a 400 square-foot room. The new facility has 3800 square feet in the main room and ten EAI 31-R's and a good bit of auxiliary analog equipment (which must give them over 500 amplifiers) plus conversion and digital equipment.

The digital equipment consists of two Recomp II machines with about 4000 words of storage each, and with built-in floating-point features. These are used for linear analysis, static checks, calculating card-set DFG functions, and production programs such as root locus, polynomial factoring, S-plane frequency response, Z-plane to S-plane, etc.

There is also a Bendix G-15 plus a 10-channel analog-to-digital and three-channel digital-to-analog Packard-Bell Multiverter. On order is a Fasitape which will allow all the punched-paper-tape machines to talk to each other—ADIOS, the D-17 airborne Minuteman flight control system, G-15, and Recomp.

The analog-to-digital converter has as a basis a 20-amplifier EAI 221-R in which the additional circuitry of Schmidt triggers, flip-flops, etc., have been installed.

An old REAC computer with approximately 20 amplifiers is kept around, possibly for sentimental reasons! It is sometimes used for small problems or isolation amplifiers, etc.

A converted F-86 as well as a wooden mockup are available for use in man-in-loop studies.

Their central reference is monitored as to the difference between the absolute values of the two supplies being used, and also by the difference between the operate and standby units. In case there is a deviation of about ± 20 mv between the absolute values of about 180 mv between the two plus supplies, an alarm sounds, indicating to operators that any solutions which are in progress might be invalid.

There is also a common ground system which consists of a U-shaped 3" copper pipe located in the cable duct, and tied through a large copper wire to a brine pit, with a copper rod driven into the ground in the basement of the building.

We haven't received a copy of the third paper of the day, "Combined Analog-Digital Simulation in Analysis of Minuteman Control System" by **J. M. Johnson,** but we found the fourth presentation ("A Human Factors Display and Simulation") actually two papers—"Comparison of Aircraft Steering Fire Control Displays" by **R. G. Kinkade** and **A. C. Poff, Jr.** (both of Autonetics) and "Analog Simulation of an Evaluation of Two Methods for Displaying Information for a Radar-Directed Air-to-Air Attack in a Piloted Interceptor" by **A. C. Poff, Jr.**—most interesting. However, either of the papers alone would be too long for presentation here, so again we will just try to give you an idea of the content and suggest that those interested in details of applications of

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this type write the authors direct for copies of the complete papers. (Both authors may be addressed c/o Autonetics, Anaheim, California.)

Kinkade on Fire-Control Steering Displays

The first of these two speakers described an experiment in which fire-control steering displays were evaluated in a flight simulator. The specific purposes of the evaluation were (1) to determine the effect of steering reference circle sizes on pilot performance and (2) to obtain additional information on the effectiveness of a moving aircraft display that provides rate of change of interceptor steering information (derivative information).

Four fire-control steering displays were employed in the comparison. Two of the displays were similar to the standard Air Force fire-control display. The only difference between these standard displays was in the size of the steering reference circle. The diameter of the steering reference circle was about one-fifth the diameter of the display on one, and about one-tenth the diameter of the display on the other.

The two remaining fire-control displays were experimental displays. Both were moving aircraft displays which provided derivative information. Steering reference circle sizes on the experimental displays were the same as those employed on the standard displays.

The operator's task was to initiate and maintain a collision course with a simulated maneuvering target. The error dot representing the target was perturbed by noise that was similar to that obtained on radar displays.

Results indicated that pilot performance is not affected by size of the steering reference circle. They also indicated that pilot performance was significantly better with the experimental displays than with the standard displays.

The superiority of the experimental displays to the standard Air Force displays probably can be attributed, in part, to the presence of derivative information in the experimental displays.

Poff on Piloted Interception

The next speaker, **A. C. Poff Jr.**, presented the more pertinent details concerned with analog simulation for the evaluation of two display configurations of air-to-air radar-directed attack information for a piloted inter-

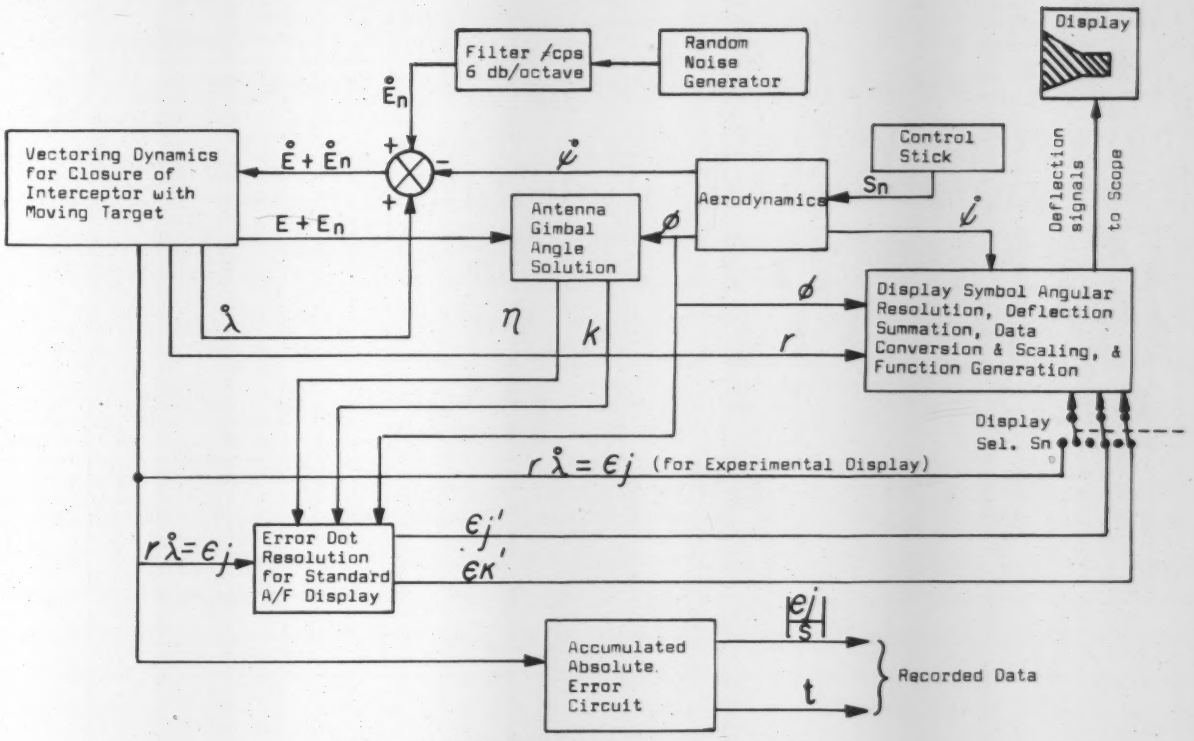

FIG. 1. BLOCK DIAGRAM of complete system.

ceptor. The block diagram (Fig. 1) shows the signal flow required to form the closed loop of the complete weapon system for a co-altitude situation for both display configurations. The accumulated absolute error circuit used to determine a figure of merit for operator performance is included.

The complete paper gives the details of the cockpit simulator, the displays, the simulation dynamics, and—to support the conclusion—all of the circuitry and mathematics involved.

ANALOG TECHNIQUES—MULTIPLIER SCALE CHANGER

ROBERT OLSEN, Electronic Defense Laboratories, Sylvania Electronic Systems, Mountain View, California

At our computing facility we have recently been running a problem that required a high degree of accuracy from the electronic multipliers. The multipliers' input remained very small for a long time interval after the start of the problem. For a solution we referred to T. R. Herndon's "Technique for Automatically Changing Scale To Maintain Multiplier Accuracy" in the Simulation Council *Newsletter* of September 1961.

After some consideration, we decided on an alternate solution, as shown in Fig. 2.

The over-all operation is similar but our circuit has several advantages:

1. Only half the relay contacts are required.
2. One less amplifier is required.
3. Since the gain change is done at an amplifier input, no special feedback resistors are required.
4. The output gain of 0.01 is obtained from two pots in series, rather than from a single pot setting.

In the problem for which this circuit was used, there were no apparent ill effects due to switching transients.

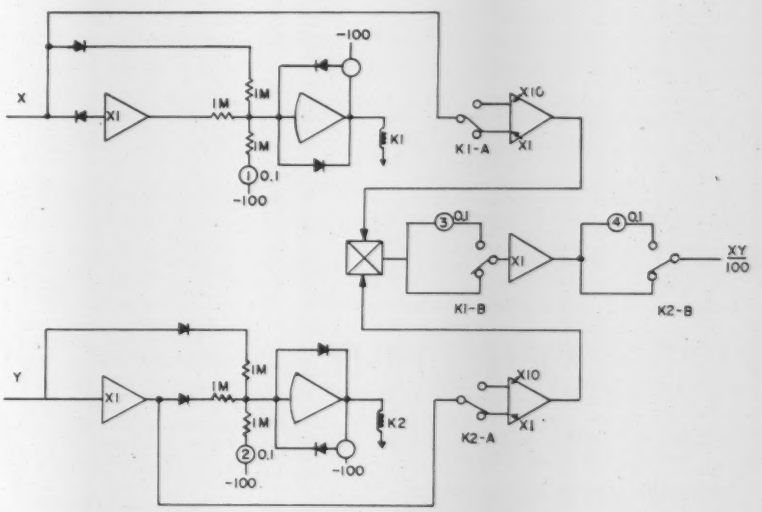

FIG. 2. SCALE changer.

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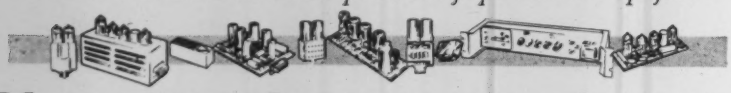

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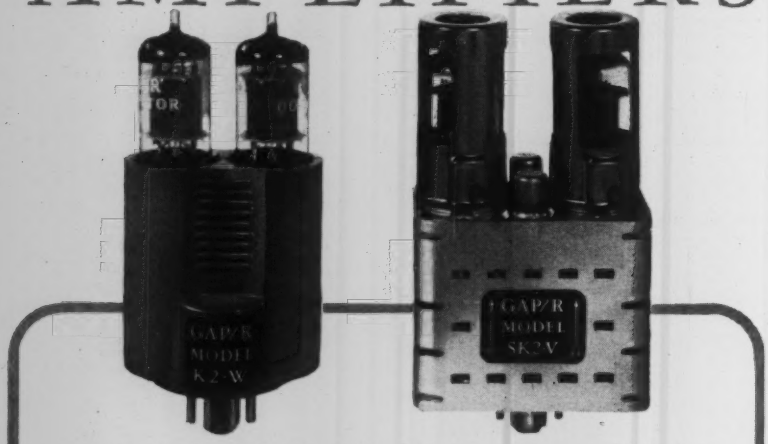

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Dear Jim:

Since my last correspondence with anyone in the Computer group at Martin Orlando, I have accepted a position here at Duke as a research associate. In particular, I am working on a research grant sponsored by The National Aeronautics and Space Administration, Spaceflight Technology Division, Goddard Space Flight Center, Greenbelt, Maryland. Generally, our objective is to increase the reliability and life span of the power supply systems of satellites.

One likely approach, and one that I have resolved to pursue fully, would be to use an analog computer to simulate the satellite power system completely, or at least to the limit of available equipment. The problem is a big one. For example, it would be desirable to include in the simulation input and output impedances of all the system components so that the effect of a fault in the system could be observed. It is also extremely nonlinear. I like to think of a simulation including square B-H loops and transistor characteristics.

My purpose in writing to you is to inquire if you know anyone, perhaps a member of the Simulation Council, making a similar study with an analog computer. I believe that a contact with a similarly interested person would result in our mutual benefit.

Give my regards to everyone in the lab. And drop me a personal note of Martin news from time to time with Simulation Council correspondence. (I recently got my application in). And please send me a Simulation Council application for another member of the staff here at Duke.

Carl Parker
Research Associate
Duke University
Durham, N. C.

He Went Thataway!

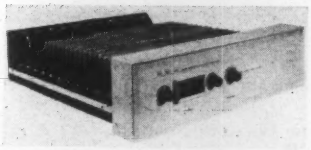
Arthur Vance to Director of Research, American Systems Inc., Hawthorne, Calif.

Gerhard L. Hollander into business for himself as Hollander Associ-

ates (734 West Maple Avenue, Fullerton, Calif.), to be concerned with design studies, evaluations, and system integration. Gary was the only American invited to the Int'l Colloquium at Hochschule Fur Elektrotechnik in Elmenau, East Germany, and gave a paper on computers in control loops on October 23, 1961.

I&CS NEW INSTRUMENTS

MULTIPLEXER



New Model LL-1 solid-state Multiplexer accepts differential inputs directly from transducers at levels as low as ±5 mv full scale and produces commutated full-scale output of ±4 v. Features include individual gain and zero adjustments for each channel. Bulletin.—*Systems Engineering Labs., Inc., Box* 9148, *Fort Lauderdale, Fla.*

CIRCLE 267 ON READER-SERVICE CARD

TRUE RMS VOLTMETER

New Model 910A True RMS Voltmeter provides 1% midband accuracy, 10-cps-to-7-mc bandwidth, plus 100 μv maximum sensitivity, measures virtually all waveforms. Has amplifier output for simultaneous oscilloscope or recorder monitoring.—*John Fluke Mfg. Co., Inc., Box* 7428, *Seattle* 33, *Wash.*

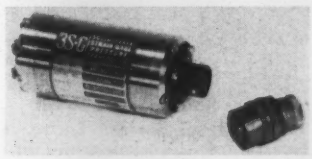
CIRCLE 268 ON READER-SERVICE CARD

COMPUTER PROGRAMMING

Two new programs, 7090 FORTRAN and 7090 Sort System, provide faster process time and increased flexibility for the large IBM solid-state computer. 7090 Fortran, written in modular form, easily accepts additions and/or modifications to the language without requiring extensive reprogramming by user. 7090 Sort System performs automatic reorganization of data stored on magnetic tape.—*Internation Business Machines Corp., Data Processing Div.,* 112 *E. Post Rd., White Plains, N. Y.*

CIRCLE 269 ON READER-SERVICE CARD

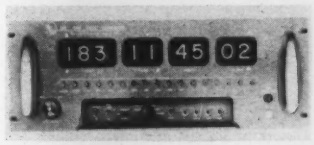
PRESSURE TRANSDUCER



New ruggedized Model 990S50 furnishes d-c-signal output of 5 v, features extreme accuracy, infinite resolution, temperature compensation, unexcelled repeatability. — *Fairchild Controls Corp., Subs. of Fairchild Camera and Instrument Corp.,* 225 *Park Ave., Hicksville, L. I., N. Y.*

CIRCLE 270 ON READER-SERVICE CARD

TIME CODE GENERATOR



New EECO-811 solid-state Time Code Generator supplies IRIG formats A, B, C, in addition to parallel code output, 10-pps and 1-pps synchronizing pulses. Digital and resolver time shift are provided for fast accurate synchronization with WWV. Frequency stability is one part in 10^8/day at ambient temperatures, or 3 parts in 10^8 over wider limits.—*Electronic Engineering Co. of Calif.,* 1601 *E. Chestnut Ave., Santa Ana, Calif.*

CIRCLE 271 ON READER-SERVICE CARD

COLLATOR

New IBM 188 punched-card alphanumeric solid-state Collator has core storage in place of relays, transistors instead of vacuum tubes to make memory function electronic rather than electro-mechanical. Up to 1,300 cards/min can be processed.—*International Business Machines Corp., Data Processing Div.,* 112 *E. Post Rd., White Plains, N. Y.*

CIRCLE 272 ON READER-SERVICE CARD

JOHN E. POLIS
manager of our Molecu-Dryer Division asks . . .

WHY DRY MORE AIR THAN YOU NEED?

AT LAST . . . you can tailor your air drying operations to the exact demand of individual instruments or valves . . . and cut your air drying costs to an all-time low.

NEW HAYES MOLECU-DRYERS® cut air drying down to size. These new models are so small you can spot them anywhere . . . on bench, wall or rack. Yet, they deliver up to 30 scfm (1800 scfh) of clean dry air . . . at working pressures up to 100 psig . . . at dewpoints as low as −60°F.

EASILY INSTALLED! Each unit, complete with two Linde Molecular Sieves® chambers, comes as an integrated package . . . ready to be tied into your air system.

EASILY MAINTAINED! Only two moving parts . . . timer and solenoid valve . . . assure continuous, automatic cycling.

Linde Molecular Sieves, with pores only 15 to 20 billionths of an inch in diameter, absorb large volumes of water . . . without melting or liquefying. Completely regenerated by automatic heating and purging, with low purge loss.

BULLETIN DBB-1 gives complete data . . . tells you how to select the right size for your dry air requirements. Write for your copy today. C. I. HAYES, Inc., 944 Wellington Avenue, Cranston, R. I.

C. I. HAYES, INC.

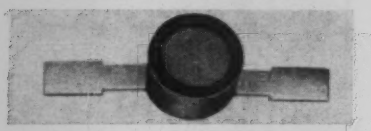
Established 1905

ELECTRIC FURNACES

It pays to see Hayes for metallurgical guidance, lab. facilities, furnaces, atmosphere generators, gas and liquid dryers, pHayes-Master (TM) power controls, induction generators.

CIRCLE 97 ON READER-SERVICE CARD

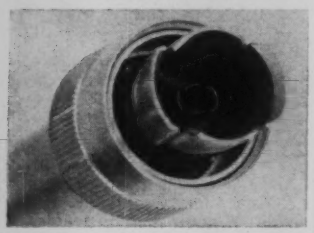
SUB-MINI THERMOSTAT



New line of Thermostats includes the 2100-1 unit specially designed for use in counter-top appliance, fire warning devices, etc. Low-cost subminiature thermostat is dust free, responds quickly and accurately with positive bi-metal snap action. Copper alloy terminals are corrosion-resistant, contacts gold plated, case is plastic. Operating range is −65° to 380°F, temperature differential 7°F, temperature tolerance ±2°F, electrical rating 2 amp/125 vac rms, size 0.600 OD, and 0.375 OAH.—*Thermal, Inc.*, 667 *Elmwood Ave., Providence, R. I.*

CIRCLE 582 ON READER-SERVICE CARD

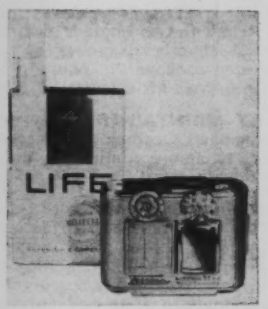
COAXIAL CONNECTORS



New Type 874 Coaxial Locking Connectors feature lower vswr (up to 8 Gc) than the N, C, BNC and UHF types; very low leakage, higher voltages; full compatibility with non-locking types.—*General Radio Co., West Concord, Mass.*

CIRCLE 583 ON READER-SERVICE CARD

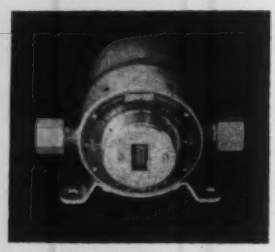
ULTRA-MINI CAMERA



New Swiss precision Camera (2½" x 2" x 1", weighing 5 oz) is smaller than all 16-mm subminiature cameras, but gives a 2-3x larger picture of 14 x 21 mm on standard 35-mm film, allowing large-scale projection with any 35-mm enlarger or projector. Automatically takes picture by pressing button, counts exposure, transports film as built-in motor offers 5-8 pictures without rewinding. Parallax-corrected Twin-lens Reflex system has 2 haze-filtered TESSINON 25 mm, f/2.8 lenses.—*Karl Heitz, Inc.*, 480 *Lexington Ave., New York* 17, *N. Y.*

CIRCLE 584 ON READER-SERVICE CARD

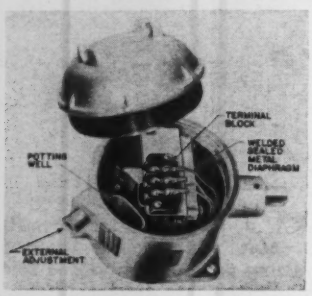
LUBE OIL METER



New Model-A-Series Lube Oil Meter, mounts on compressors of all types, provides continuous check of make-up oil. Functions on both gravity-fed or pressure-fed lubricating systems with no minimum flow requirement. Measures as little as one gallon/month. Bulletin.—*Service Recorder Co.*, 1013 *Rockwell Ave., Cleveland* 14, *Ohio.*

CIRCLE 585 ON READER-SERVICE CARD

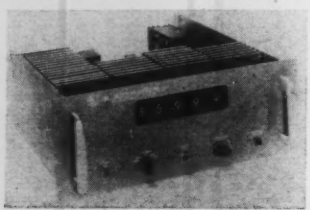
PRESSURE SWITCHES



New explosion-proof diaphragm Pressure Switches have guaranteed set and re-set accuracy of ±½%, can be adjusted externally, have pottable electric outlets, integral terminal blocks. Actuate at 0.1" Hg with test pressure to 10 psi, and up to 300 psi test pressure at settings to 150 psi. Pressure connection is ¼" NPT female, single-setting and dual-control models available.—*Barksdale Valves*, 5125 *Alcoa Ave., Los Angeles* 58, *Calif.*

CIRCLE 586 ON READER-SERVICE CARD

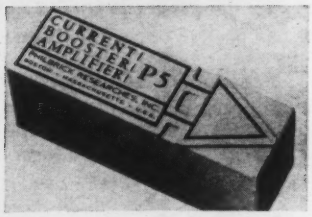
SHAFT ANGLE TRANSLATOR



New EECO 780 Shaft Angle Translator produces visual display and BCD data outputs. Accepts up to 16 Gray or binary coded digits from brush or photo-optical types of shaft encoders with resolution of 0.01°. Output accuracy is ±1 digit.—*Electronic Engineering Co. of California*, 1601 *E. Chestnut Ave., Santa Ana, Calif.*

CIRCLE 587 ON READER-SERVICE CARD

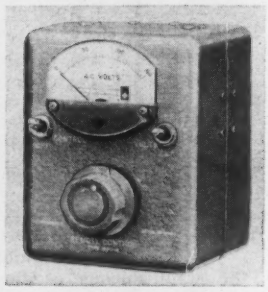
CURRENT BOOSTER AMPLIFIER



New P5 solid-state Current Booster Amplifier increases available output current to as high as ±20 ma at ±10 v when used as a follower with Philbrick P2 or other similar operational amplifiers. Input is directly coupled to transistor base. Maximum input signal is ±12 v, with min input impedance of approx. 50 K. Amplifier gain is 0.99, typically.—*Philbrick Researches, Inc.*, 127 *Clarendon St., Boston, Mass.*

CIRCLE 588 ON READER-SERVICE CARD

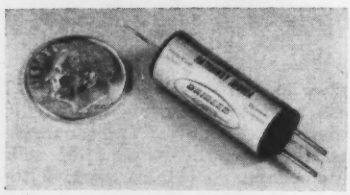
REMOTE CONTROL FOR VARIAC



New Type 1590-A remote control affords operation of motor-driven (Variac®), variable autotransformers from a remote point, positions itself automatically to any required voltage from 0 to 140 v. Complete system is a closed-loop servomechanism, operating on the difference in voltage setting between the command and the driven auto-transformers. Tracking accuracy is ±2% of line voltage.—*General Radio, West Concord, Mass.*

CIRCLE 589 ON READER-SERVICE CARD

SENSITIVE RELAY



New Relay with Drireed contact features unusual resistance to vibration and shock, extremely long life and reliability, utilizes miniature gold plated, glass scaled contact set. Life expectancy 10,000,000 operations at 50 ma/115 v, resistive.—*Hathaway Denver*, 5800 *E. Jewell Ave., Denver, Colo.*

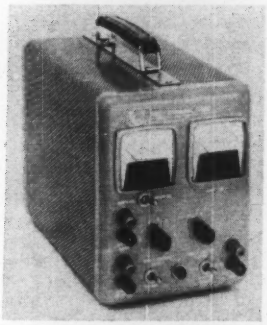
CIRCLE 590 ON READER-SERVICE CARD

ELECTRONIC MICROMETER

New Model HDR Carson-Dice Electronic Micrometer, not a comparator but a true screw-thread measuring instrument, displays on four-digit counter reading to a 20-millionths inch. Permits measurements on conducting parts at zero pressure with no measureable deflection of fragile or compressible part. Special tip for non-conducting materials provides adjustable hold-down pressures of 1.5, 5, 10 and 20 grams. —*J. W. Dice Co., Englewood, N. J.*

CIRCLE 273 ON READER-SERVICE CARD

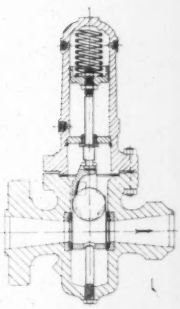
DYNAMIC LOAD



New EECO 705 Dynamic Load measures internal a-c impedance of d-c power supplies up to 32 v at frequencies from 20 cps to 1 Mc, with d-c current between 50 ma and 2.5 amp, or with a-c current up to 4 amp, peak-to-peak. Meters indicate peak-to-peak supply, a-c output current, power supply, d-c output current and power supply d-c output voltage. Front panel terminals connect to signal generator and oscilloscope to monitor distortion of power supply output a-c signal.—*Electronic Engineering Co. of Calif.*, 1601 *E. Chestnut Ave. Santa Ana, Calif.*

CIRCLE 274 ON READER-SERVICE CARD

BALL VALVE ACTUATOR



New no-leakage self-contained and self-regulated Integral Cylinder Valve handles a wide range of fluids, including high viscosity liquids, in split-second operation under any pressure. Suitable for atomic applications. — *General Kinetics Corp.*, 197 *S. Van Brunt St., Englewood, N. J.*

CIRCLE 275 ON READER-SERVICE CARD

THE HP5 SERIES CYCL-FLEX FOR
TIME CONTROL

Yes, our *New* Cycl-Flex Timer is as easy to adapt and change as a simple electric plug.

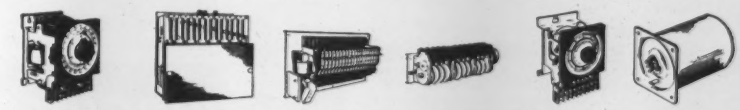
Don't let automation troubles get you down! . . . use our New Cycl-Flex for TIME CONTROL functions. Should your automatic controls fail for any reason, you can trace your trouble by plugging-in a spare timer. Movement of the TIME pointer indicates whether trouble is in the input or the output circuits.

Eagle's New Cycl-Flex Timer has been enthusiastically adapted by leading manufacturers of molding presses, dielectric heaters, machine tools and feed controls.

Write for Bulletin 125 or call your local Eagle Representative. He's listed in Sweet's Product Design File, Section 7d, or in Thomas Register.

SPECIFICATIONS • 10 sec. to 60 hr. dial • 2 instantaneous switches • 2 delayed switches • 12 terminals • Resets in 1/3 sec. • Mounts in 3 1/8" dia. hole

MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS AVAILABLE



Precision Interval Timers | Multiple Circuit Timers | Heavy-Duty Step Switches | Multiple Cam Timers | Predetermined Counters | Hermetically Sealed Timers

BLISS

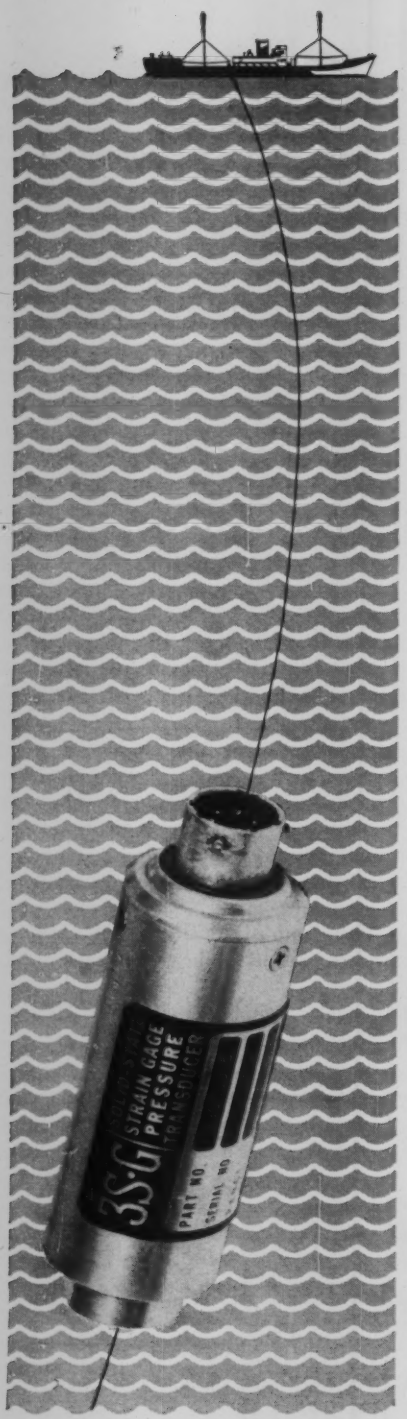
EAGLE SIGNAL COMPANY • Moline, Illinois
INDUSTRIAL DIVISION
A DIVISION OF THE GAMEWELL COMPANY, AN E.W. BLISS COMPANY SUBSIDIARY

CIRCLE 98 ON READER-SERVICE CARD

LONG LINES NEED STRONG SIGNALS

THE 3S-G SILICON SEMICONDUCTOR STRAIN-GAGE PRESSURE TRANSDUCER

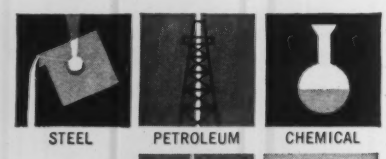
Has a Signal Output of 5 v. d. c.



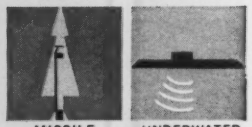
For remote pressure measurement via long lines—under water or above ground—you need a transducer that delivers a high-output signal without additional amplification. The only answer is the new Fairchild 3S-G. It has a 5 v. d.c. output. And it uses semiconductor materials with piezoresistive characteristics as a sensing element.

Extraordinarily accurate (±.003%/degree F error band is not uncommon) in the roughest environment, the tough 3S-G has infinite resolution, self-contained calibration, temperature compensation, and unexcelled repeatability. It is also available with low output (5mv. to 5 v. d.c.), low-pressure gage and absolute (0-10 to 0-100 p.s.i.), high-pressure gage and absolute (0-100 to 0-10,000 p.s.i.), and high-line low-differential (±10 to ±10,000 p.s.i.d.). All versions operate from −65° to 250°F in practically all gaseous and liquid media, including liquid oxygen, strong alkalies, corrosive acids, and high-energy fuels. All are designed to replace strain-gage pressure transducers now being used by industry and the military.

For more information about the 3S-G silicon-semiconductor strain-gage pressure transducer, write Dept. 51 ICS.



wide application in control systems for defense & industry



FAIRCHILD
CONTROLS CORPORATION

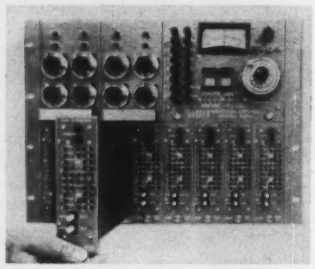
a Subsidiary of Fairchild Camera & Instrument Corporation

225 PARK AVE., HICKSVILLE, L. I., NEW YORK
6111 E. WASHINGTON BLVD., LOS ANGELES, CAL.

ANOTHER FINE PRODUCT OF FAIRCHILD RESEARCH

CIRCLE 99 ON READER-SERVICE CARD

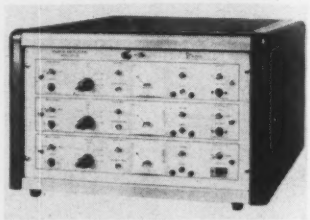
ITERATIVE AN COMPUTER



New 3200-Series Iterative Analog Computer has 50 amplifiers, incorporates a 0.05% solid-state multiplier and stored-program function generators, 2" x 7" modules slide into front of computer.—*Donner Scientific Div., Systron-Donner Corp., Concord, Calif.*

CIRCLE 276 ON READER-SERVICE CARD

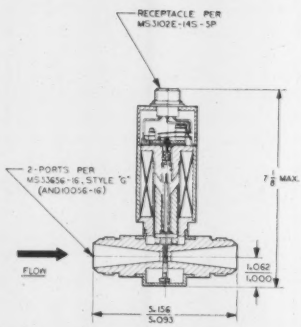
POWER AMPLIFIER



New self-contained Model 8003M Three-Channel Power Amplifier for piezoelectric accelerometers is composed of cathode follower, voltage and power amplifiers providing low impedance output signal of 10 v peak-to-peak at 300 ma that can be fed directly into a mirror-galvanometer-type recording oscillograph.—*Columbia Research Labs., MacDade Blvd. & Bullens Lane, Woodlyn, Pa.*

CIRCLE 277 ON READER-SERVICE CARD

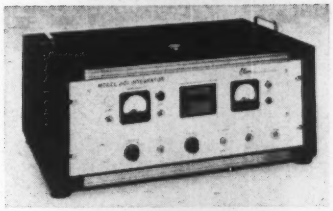
CRYOGENIC SOLENOID VALVE



New Series V-41600 high-flow floating-seal Valve features arc-welded leak-proof design in which media contact only all-metal surfaces, no seals. Withstands −320° to +140°F, maximum operating pressure of 50 psi. Maximum actuation time is 50 msec. Flow is equivalent to 0.850"-dia sharp-edge orifice.—*Valcor Engineering Corp., 365 Carnegie Ave., Kenilworth, N. J.*

CIRCLE 278 ON READER-SERVICE CARD

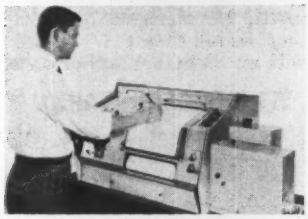
INTEGRATOR



New Model J101B Integrator integrates amplified signals derived from transducers of radiation, temperature, displacement, moisture, humidity, light, color, strain, weight, absorption, etc. An analog accumulator, it can be used with current and voltage indicators (6-decimal digit counter and 2½" meter), recorders, or instrument with full-scale output of one ma at 10-to-100 volts. Accuracy is 1%.—*Elcor, Inc.*, 1225 *W. Broad St., Falls Church, Va.*

CIRCLE 279 ON READER-SERVICE CARD

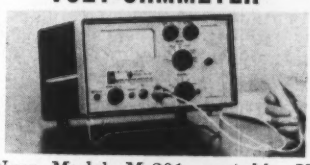
SPECTROPHOTOMETER



New Cary Model 15 Recording Spectrophotometer features double monochromomator with wavelength range 1750-8000 Angstroms; new recorder with coupled scan and chart drive; and improved cell optics giving reduced beam size (1.0 x 0.3cm). —*Applied Physics Corp.*, 2724 *S. Peck Rd., Monrovia, Calif.*

CIRCLE 280 ON READER-SERVICE CARD

VOLT-OHMMETER

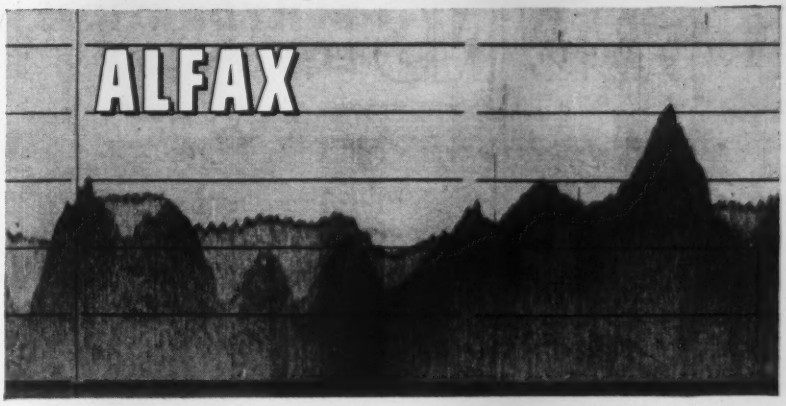


New Model M-201 portable Volt-Ohm Meter a combined a-c voltmeter, d-c voltmeter, and ohmmeter, features fold-away handles at both ends of metal case, four-shelf compartment with hinged door in front panel for storage of ground lead assembly and three probe assemblies, wind-up power cord, and special swing-away metal stand attached to front feet permitting tilting to 12° angle.—*Borg Warner Controls, Div. Borg-Warner Corp., Box* 1679, *Santa Ana, Calif.*

CIRCLE 281 ON READER-SERVICE CARD

For More Information on Products Listed Please Circle the Corresponding Number on Reader-Service Card

There's nothing as simple or satisfactory as recording with



Recording of Halifax Bay in Nova Scotia illustrates the discrete recording at a 50 fathom interval. Note that the tone shading derived from Alfax Paper in this instant graphic recording captures more information.

No matter what you need to record – Alfax electrosensitive paper can help you do it better, easier, faster.

Progressive innovators have obtained *vital information never before recorded* in:

- Satellite Tracking
- Brain Wave Study
- Sonar
- Seismic Profiling
- Computer Readout
- Ultrasonic Flaw Detection
- Long Range Radar
- Frequency Analysis

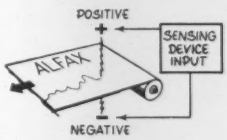
with unexpected breakthroughs in many other areas.

Why? Because of
ALFAX EXCLUSIVES

- broad, dynamic response capable of 22 distinct tone shades
- remarkable expansion at low level signal, where slight variation may provide critical information
- records in the sepia area of the color spectrum where the eye best interprets shade differentials in diminishing or poor light of laboratories, temporary field locations, briefing centers, planes or ships.
- writing speed capabilities from inches per hour up to 1400 inches/second (a speed range from 1 to 84000)
- captures 1 micro second pulse or less
- dynamic range as great as 30 db
- integration capability to provide for signal capture in signal to noise ratio conditions worse than 1 to 4
- resolution capabilities of one millisecond equal to one inch of sweep
- accuracy capabilities of a few thousandths of an inch by generation of simultaneous grids with signal to permit accurate location of recorded transients
- sensitivity to match the most advanced sensing devices

Alfax . . .

- requires no further processing (thus no delay of information accumulation — no delay of decisions)
- recordings are permanent — can be stored indefinitely under all temperature extremes — even frozen, thawed and then recorded
- eliminates objectionable side effects — (proved completely non-toxic, non-irritant, odor-free)
- provides direct copies by Ozalid or Bruning processes
- may be written on or erased without damage to recording



Alfax provides a simple, uncomplicated recording technique — having a broader application range than any other graphic recording media.

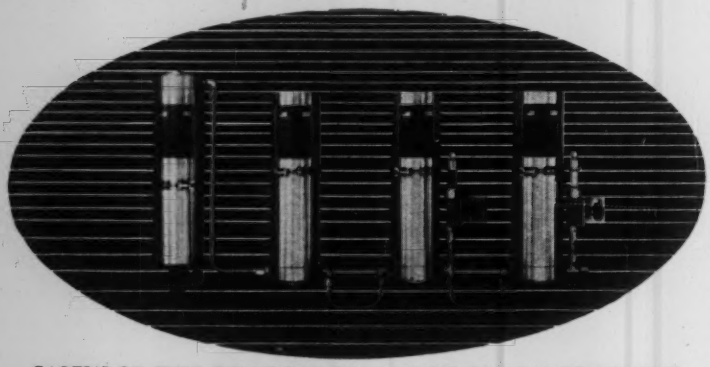
By merely passing a low current through Alfax everything from the faintest trace signal of micro-second duration to slow but saturated signal can be seen *instantly, simultaneously.*

Alfax electrosensitive paper is available without restrictions to you as an instrument manufacturer, electronic systems company, scientist or experimenter. *Write for complete information to . . .*

ALFAX

CIRCLE 100 ON READER-SERVICE CARD

ROBBINS DEHYDRATION EQUIPMENT



CARTRIDGE TYPE DEHYDRATION & PURIFICATION EQUIPMENT

PRECISION MADE FOR PERFORMANCE!

CARTRIDGE TYPE PRESSURES TO 12,000 PSI ... DEWPOINTS TO —100°F ARE STANDARD SAFETY FACTOR OF 4 TO 1 ... OIL VAPOR REMOVED AS LOW AS 0.3 PPM/W TOTAL HYDROCARBONS

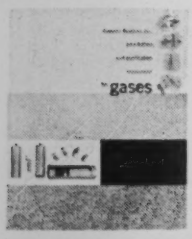
Robbins disposable desiccant cartridge type drier and purifier equipment is carefully engineered for maximum effectiveness. Chambers are leakproof and cartridges are by-pass proof. Moisture and contaminants in the gas stream are retained in the cartridges, and do not contact the chambers. No tools are needed to change cartridges. Can also be supplied as complete systems, from single to four-chamber, for six maximum pressure ranges and in two maximum flow capacities for each pressure. Porous stone mechanical filters rated at 10 microns are available, as well as fiberglass filterpack cartridges rated at .3 microns.

DESIGNED TO SAVE YOU MONEY!

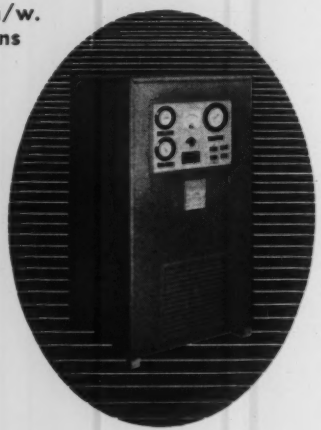
REFRIGERATION SYSTEMS

Oil Vapor Removed to Less than 1 ppm/w.
Foreign Particles Removed to 10 microns
Dewpoints to —120°F.
Continuous or Intermittent Operation
Automatically Controlled
Need No Defrosting

Robbins' refrigeration type gas drier and purification units are individually engineered to meet your needs for the removal of moisture and oil from air, nitrogen, hydrogen, helium, and other gases. Use of refrigeration increases life of desiccant cartridges 8 times with substantial operating cost savings.



Write TODAY for 20-page illustrated brochure in color!



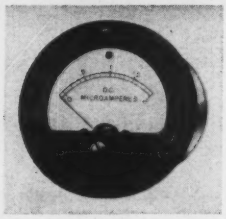
REFRIGERATION TYPE DEHYDRATION SYSTEMS INDIVIDUALLY ENGINEERED

ROBBINS Aviation Inc.

3817 S. Santa Fe Ave.
Los Angeles 58, California
LUdlow 9-5221

CIRCLE 101 ON READER-SERVICE CARD

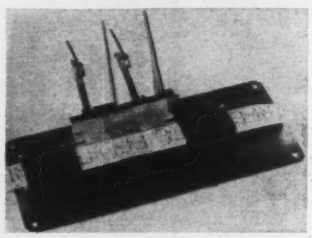
SENSITIVE MICROAMMETERS



New Series HSR high-sensitivity transistorized Microammeters, available in 1½", 2½", and 3½" sizes, meet MIL-M-10304 specs. Operate from any 3-to-250 vdc supply with current drain of only 80 to 200 μamp depending on supply voltage. Standard ranges include 0-2, 0-4, 0-5, 0-10, 0-15, 0-20 μamp with zero left, and 1-0-1, 2-0-2, 4-0-4, 5-0-5, 10-0-10 μamp with zero center. Available also as millivolt meters in various ranges, and as megohm meters suitable for use as d-c meggers for insulation testing.—*DeJur-Amsco Corp., Instrument Div., Northern Blvd., at 45th St., Long Island City 1, N. Y.*

CIRCLE 282 ON READER-SERVICE CARD

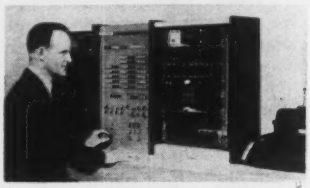
SPLICER AND TAPE



New punched-tape Splicer-and-Splicing-Tape splice 5-to-8 channel punched tape. Splicer has built-in squaring shears for butt splices, has 4" x 9" base, weighs 4 lb. Pregummed and fully punched tape is available in 11/16", ⅞" and 1" widths, 10', 25' and 100' lengths.—*Dresser Products Inc., Box 2035, Providence 5, R. I.*

CIRCLE 283 ON READER-SERVICE CARD

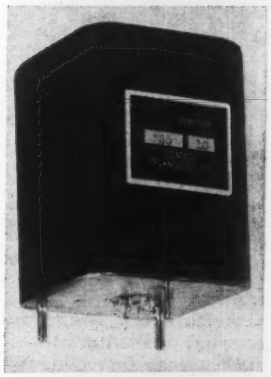
DESK SIZE COMPUTER



New binary Univac Military Digital Trainer occupies 8 cu ft, operates from 60 cycle/110 vac power, dissipating 750 watts max. Characteristics include high-speed magnetic core memory with 512 fifteen-bit words of random access storage, single address instruction repertoire, solid-state parallel logic circuitry, easy accessibility.—*Univac, Div. Sperry Rand Corp., Military Dept., Univac Park, St. Paul 16, Minn.*

CIRCLE 284 ON READER-SERVICE CARD

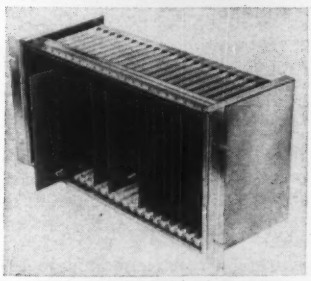
ISOLATION AMPLIFIER



New Model 260 400-cps Isolation Amplifier, with absolute gain as well as linearity maintained within ± 0.1% over the entire temperature range, features gain of 40, 20,000-ohms input impedance and maximum output voltage of 40 rms.—*Control Technology Co., Inc.*, 41-16 29*th St., Long Island City* 1, *N. Y.*

CIRCLE 285 ON READER-SERVICE CARD

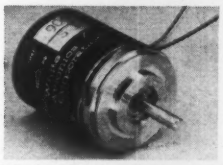
DIGITAL CARD CIRCUITS



New line of Card Circuits in the medium speed range achieves inherent reliability of transistor switching circuits without use of redundant elements. All components are de-rated to 50%. Power supply voltages required are +12 v, −6 v and −24 v, regulated within ± 3%. Temperature range is 0° to 55°C. Output signals are 0 and −6 v. 7½" x 6" x $\frac{1}{8}$" glass-bonded epoxy.—*Drexel Dynamics Corp., Horsham, Pa.*

CIRCLE 286 ON READER-SERVICE CARD

DIGITAL TRANSDUCER



New Model Series 900 photoelectric Digital Rotary Transducer provides frequency output as function of angular velocity, furnishes direct digital measurements of shaft speeds to 30,000 rpm by coupling output to digital counter. Adaptable to binary, decimal and degree systems for digital computers.—*White Avionics, Terminal Dr., Plainview, N. Y.*

CIRCLE 287 ON READER-SERVICE CARD

NEW ACRAGAGE® CONVENIENCE

2 SECONDS TO OPEN
2-WAY CONNECTION
Outside threaded for ½" connection
Inside threaded for ¼" connection
NEW Poly-Clip Ring for Instant Opening
New Duo Connector Fits ¼" and ½" Sizes

No more retainer-ring corrosion . . . no more glass breakage when prying out stubborn rings!

This new polypropylene ring snaps in and out instantly without special tools . . . and gives you a positive, weather-tight closure.

Now standard on all phenolic Acragage cases, it is also available on aluminum or iron cases for special applications.

There's added convenience, too, in our exclusive new Quarter/Half Connector. The single fitting is threaded inside and out for standard ¼" and ½" connections.

For complete information on Acragage styles, ranges and prices, write today for Catalog VL-G.

Robertshaw®

MR. CONTROLS

Robertshaw-Fulton Controls Company

FULTON SYLPHON DIVISION, KNOXVILLE 1, TENNESSEE

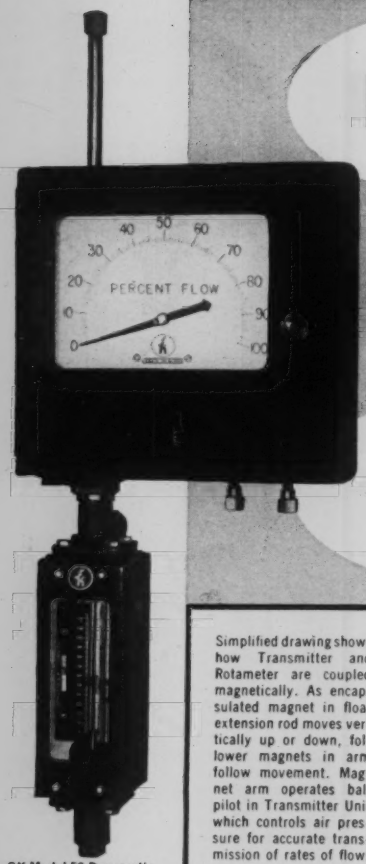
CIRCLE 102 ON READER-SERVICE CARD

NEW

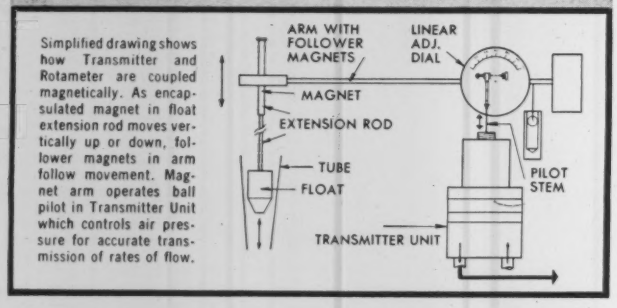
PNEUMATIC TRANSMITTING ROTAMETER

offers

"NEVER-BEFORE" *features*



SK Model 58 Pneumatic Transmitter with SK Safeguard Rotameter.



Simplified drawing shows how Transmitter and Rotameter are coupled magnetically. As encapsulated magnet in float extension rod moves vertically up or down, follower magnets in arm follow movement. Magnet arm operates ball pilot in Transmitter Unit which controls air pressure for accurate transmission of rates of flow.

Here's a new design in Pneumatic Transmitters—the Model 58 by SK's INSTRUMENT DIVISION. Designed for use with either SK Safeguard or Metal Tube Rotameters, these "position-balance" type transmitters communicate fluid rates of flow to remote located indicators, recorders, controllers, or integrators. Here are some of many important advantages offered by the Model 58.

- Calibration adjustments are simple without cams, special devices.
- Exclusive magnet design (patent applied for) provides evenly-distributed field without drag on metering float.
- Transmitter Unit of pneumatically-coupled section design has no mechanical linkages, assures high accuracy.
- Percent scale suitable for any calibration. Factor tag on dial face permits conversion of scale units to flow quantity.
- Varying supply air pressure (between 20 and 25 psig) will not affect accuracy.
- Large scale and pointer permit easy, accurate reading.
- Removal of transmitter not required for cleaning main valve or pilot orifice.

Details on this new Transmitter are covered in Bulletin 18N which is available on request.

QUICK DELIVERY FROM STOCK

For Immediate Delivery, Standard SK Jet Ejectors, Rotameters, and Flow Indicators are stocked in Cornwells Heights (Phila.), Pa., Houston, Texas, and San Francisco, Calif.

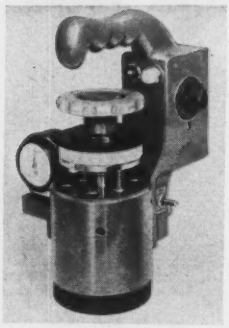
Schutte and Koerting COMPANY

INSTRUMENT DIVISION

2225 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.

CIRCLE 103 ON READER-SERVICE CARD

HARDNESS TESTERS



Two new Hardness Tester models use loading and penetrators to ASME and ASTM specs. Introdyne Model H-1 is horizontal, has no weights or levers. Portable Magnedyne model attaches electromagnetically to ferromagnetic material, has adapter shoe to test flat as well as curved surfaces from 2" to any larger radius. Bulletins.—*Advance Industries, Inc., Instrumentation Div., Box* 128, *South Action, Mass.*

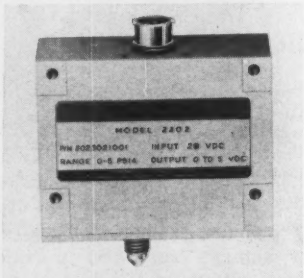
CIRCLE-288 ON READER-SERVICE CARD

DC POWER

New silicon-rectifier Model 10-C D-C Power Source features special panel switching system to provide constant 115-vdc output at load currents up to 3.0 amp under a-c input voltages ranging from 115v (±10v) and 230 (±20v), single phase, at 25 to 60 cps; very low a-c ripple. Bulletin.—*H. O. Boehme, Inc.,* 915 *Broadway, New York* 10, *N. Y.*

CIRCLE 289 ON READER-SERVICE CARD

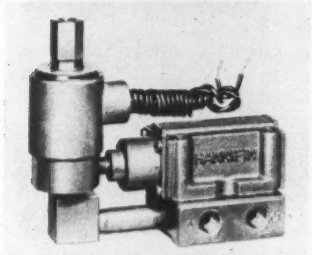
PRESSURE TRANSDUCER



New Model 2302 dc/dc variable-reluctance Pressure Transducer operates from unregulated 28-vdc aircraft and missile power supplies. Details in bulletin.—*Bourns, Inc.,* 6135 *Magnolia Ave., Riverside, Calif.*

CIRCLE 290 ON READER-SERVICE CARD

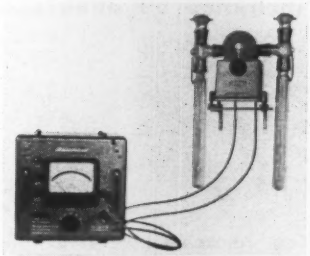
SOLENOID ACTUATORS



New line of explosion-proof solenoid Actuators for CC-Series pilot-operated air valves is suitable for Class 1, Group D and Class 2, Groups F and G hazardous applications. Valve features compact design, leak-proof construction, and large air flow capacity.—*Hannifin Co., Dept.* 302, 501 *S. Wolf Rd., Des Plaines, Ill.*

CIRCLE 291 ON READER-SERVICE CARD

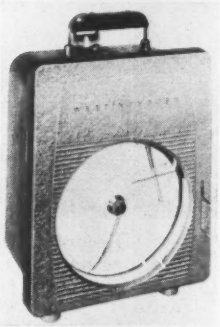
MICRO BALANCE



New Sartorius Electrona Electronic Recording Micro Balance, for work in normal or controlled (vacuum) atmospheres, features drastically-reduced oscillation period and disturbing effects of mechanical vibrations, and atmospheric conditions. Multi-channel recorders can be used for simultaneous recording of weight, temperature, and other data. Bulletin.—*Brinkmann Instruments, Inc.*, 115 *Cutter Mill Rd., Great Neck, N. Y.*

CIRCLE 292 ON READER-SERVICE CARD

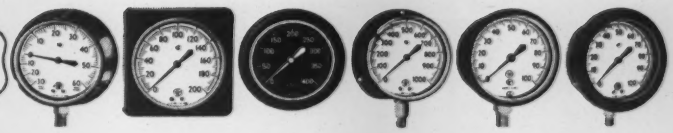
ELECTRICAL RECORDER

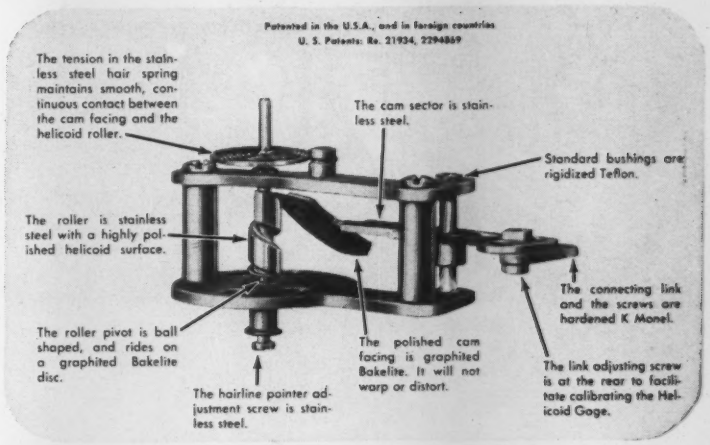


New Type 45 Westinghouse Recorder for current and voltage measurements features sealed plastic sac and tubing to prevent evaporation and coagulation of ink. Pen is made from half-hard Inconel tubing supplied by *Superior Tube Co., Norristown, Pa.*

CIRCLE 293 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.




Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy*... on the toughest jobs

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

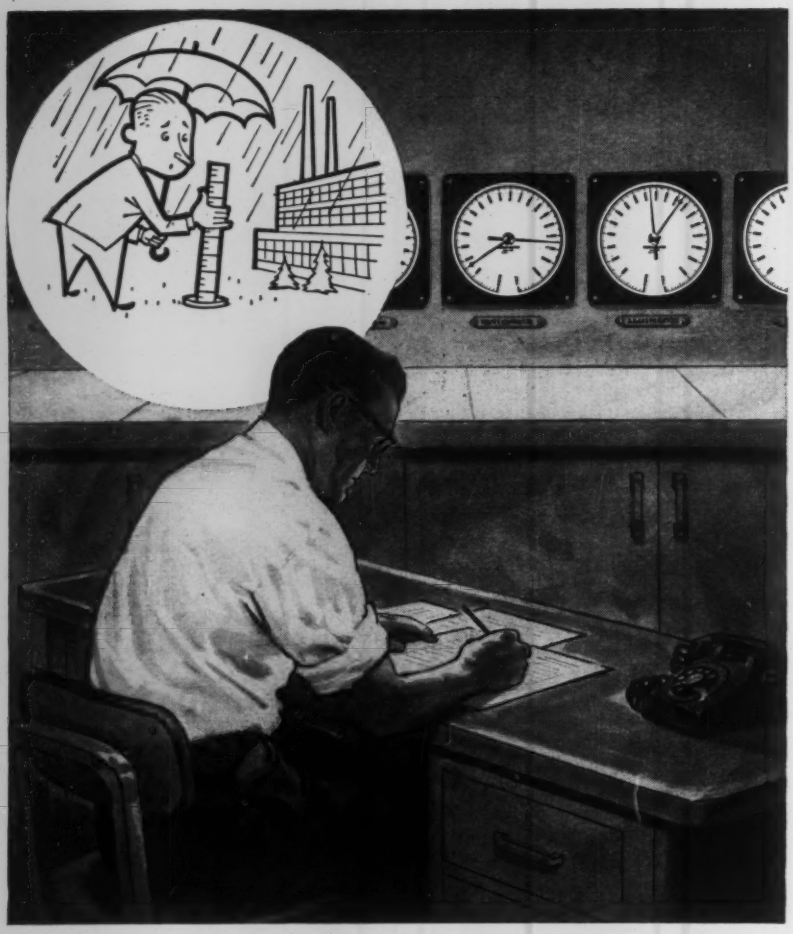
HELICOID GAGES

Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

ACCO

CIRCLE 104 ON READER-SERVICE CARD



Take the legwork out of liquid measurement

Here's practical liquid measuring—the modern way... without roaming all over the lot! Liquidometer Gauges let you inventory distantly stored liquids at a glance.

Completely automatic Liquidometer Gauges can be located as far as 250 feet from tanks. Think what this centralized system can mean in man-hours saved—let alone the additional safety of personnel who no longer have to trudge to, or tamper with, hard-to-get-at tanks.

Simple to install, and requiring no maintenance, Liquidometer Gauges measure virtually all liquids conveniently, continuously, and correctly. There's a type available for practically every liquid measuring application.

For complete details, write

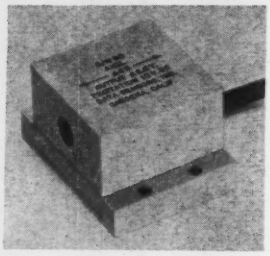
LIQUIDOMETER INSTRUMENTS

THE LIQUIDOMETER CORP.

Dept. E, LONG ISLAND CITY 1, NEW YORK

CIRCLE 105 ON READER-SERVICE CARD

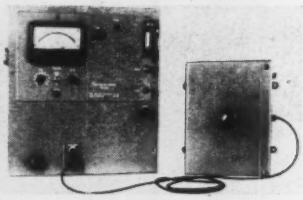
LINEAR ACCELEROMETERS



New photo-resistive Models AH1L and AH2L High-Output Linear Accelerometers produce 5 v or ±2.5 v output without amplification from 10-vdc excitation. Features include 500% overload of rated range, operating temperature range from −65° to +250°F, and excellent stability.—Data Sensors, Inc., 13112 Crenshaw Blvd., Gardena, Calif.

CIRCLE 294 ON READER-SERVICE CARD

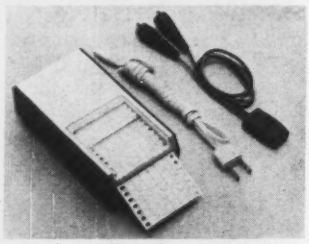
INFRARED CO ANALYZER



New portable Infrared Carbon Monoxide Analyzer monitors carbon monoxide concentration in air pollution studies, tunnels and garages, chemical plants, gas mixtures within closed tanks, etc. Standard unit has switch-selected ranges of 0 to 0.05% and 0.03 to 0.25%; is available with integral sampling pump, flowmeter, and pressure regulator.—*Gelman Instrument Co., 106 N. Main St., Chelsea, Mich.*

CIRCLE 295 ON READER-SERVICE CARD

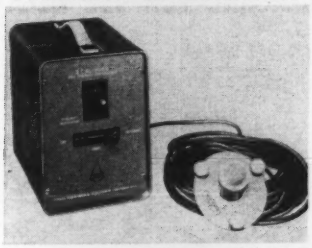
MINI RECORDING VOLTMETER



New 20-oz Recorder Voltmeter makes legible, permanent record on paper tape (2½″ x 35′) moving at 12″/hr; features simplified paper loading, expanded scale, ruggedness and low cost. It is inkless; uses smudgless, pressure-sensitive paper unaffected by heat, cold, moisture, etc. Regular scale and expanded scale models.—*Amprobe Instrument Corp., 630 Merrick Rd., Lynbrook, N. Y.*

CIRCLE 296 ON READER-SERVICE CARD

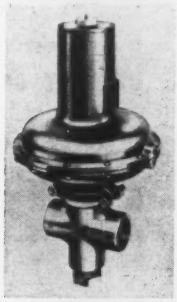
SUNLIGHT INTEGRATOR



New portable battery-powered Sunlight Integrator employs solion tetrode for integration, records directly in cal/sqcm with 2% accuracy over periods of minutes to days.—*Texas Research and Electronic Corp., Meadows Bldg., Dallas, Tex.*

CIRCLE 297 ON READER-SERVICE CARD

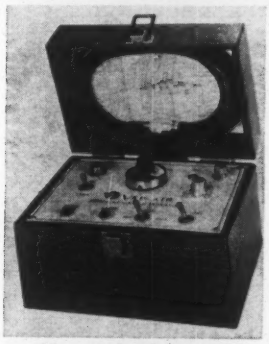
DUMP VALVE



New Type 70-23 diaphragm-operated Dump Valve is primarily for ON-OFF applications in high pressure service. Has reversible actuator, interchangeable seat cages, and same inner valve for all orifice sizes. Bulletin. —*Black, Sivalls & Bryson, Inc.*, 7500 *E. 12th St., Kansas City* 26, *Mo.*

CIRCLE 298 ON READER-SERVICE CARD

TRANSIENT VOLT INDICATOR



New self-contained, portable Transient Voltage Indicator detects and records occurance of undesirable voltage pulses down to one μsec. Indicator light with memory feature permits unattended operation for as long as 3 weeks. Two voltage ranges are available—0-200 at ±5% full scale accuracy and 0-2000 v (±2%). Input impedance is 5 mmfd in shunt with 1 megohm, both ranges.—*Vapor Heating Corp., Vap-Air Div.*, 6444 *W. Howard St., Chicago* 48, *Ill.*

CIRCLE 299 ON READER-SERVICE CARD

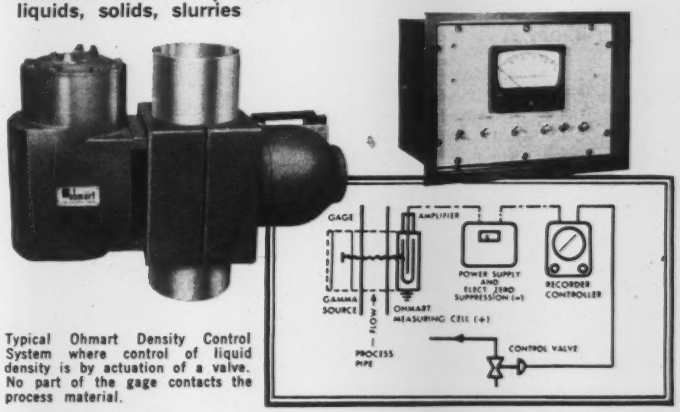
ohmart

NUCLEAR

gaging solves many processing problems

OBTAIN CONTINUOUS, CLOSE LIMIT CONTROL OF:

- Specific gravity and density of liquids
- Percent solids or moisture of slurries
- Level or interface position of liquids, solids, slurries
- Dry solids flow (continuous weighing)
- Thickness or weight of moving webs of sheet materials



Typical Ohmart Density Control System where control of liquid density is by actuation of a valve. No part of the gage contacts the process material.

EXCLUSIVE OHMART ADVANTAGES: Ohmart gages have a precision and repeatability of ± 2% of full scale or better, with ranges as narrow as 0.025 s.g.u (4°Be., 5°Tw., 10°API, 5% solids) available. Ohmart systems operate with high signal-to-noise ratio; are unique in their stability and simplicity. Measuring cell has infinite life. Low-drift circuit requires only 5-minute semi-monthly standardization check. Rugged gage construction withstands severe atmospheric and mechanical conditions. Installation and maintenance costs are low. *Look to Ohmart to improve your process control. Performance to specification is guaranteed!* Write for literature.

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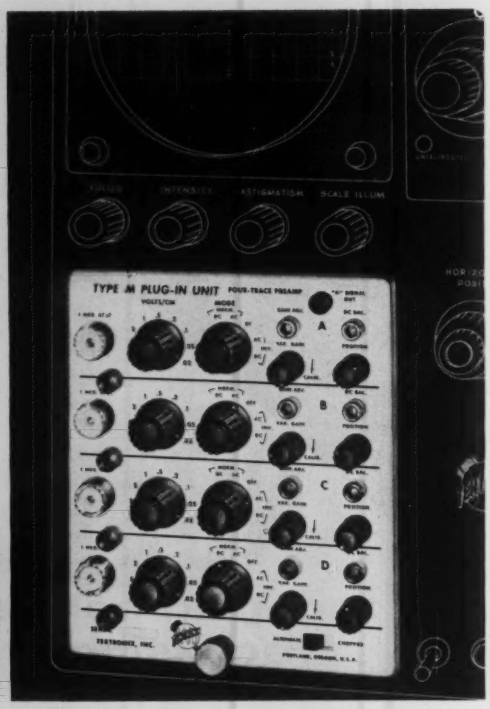
THE OHMART CORPORATION
4243 Allendorf Dr., Cincinnati 9, O.

Engineering representatives in principal areas

CIRCLE 106 ON READER-SERVICE CARD

NEW
4-TRACE
PREAMPLIFIER

for Tektronix Oscilloscopes that accept letter-series plug-in units



TYPE M UNIT Seventeenth in the letter-series of plug-in units, the new Type M Unit adds multiple-trace displays to the wide range of applications possible with your Tektronix oscilloscope.

With a Type M Unit, you can observe up to four signals—either separately, or in any combination.

Independent controls for each amplifier channel permit you to position, attenuate, invert input signals as desired.

Other convenient preamplifier features—such as triggered or free-running electronic switching . . . ac-coupling or dc-coupling . . . and, after initial hookup, little or no cable switching—ideally suit the new Type M Unit for multiple-trace presentations in the laboratory or in the field.

CHARACTERISTICS

Operating Modes—Any combination of one to four channels electronically switched—at the end of each sweep or at a free-running rate of about 1 mc (1μsec width samples). Or each channel separately. *Channel Sensitivity*—20 mv/cm to 10 v/cm in 9 calibrated steps. Continuously variable uncalibrated between steps, and to 25 v/cm. *Channel A Signal*—available on front panel for optimum triggering in some applications. *Frequency Response and Risetime*—With Type 540-Series and Type 550-Series Oscilloscopes dc to 20 mc, 17 nsec. With Type 531A, 533A, 535A Oscilloscopes dc to 14 mc, 25 nsec. *Constant Input Impedance*—at all attenuator settings.

Type M Plug-in Unit . . U.S. Sales Price, f.o.b. Beaverton, Oregon . . . $455.00

For a demonstration of this new 4-Trace Preamplifier, please call your Tektronix Field Engineer.

Tektronix, Inc.

P. O. BOX 500 · BEAVERTON, OREGON / Mitchell 4-0161 · TWX—BEAV 311 · Cable: TEKTRONIX

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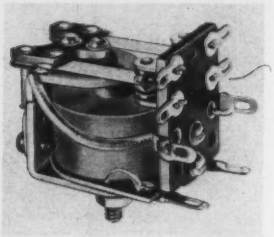
ENGINEERING REPRESENTATIVES: Kentron Hawaii Ltd., Honolulu, Hawaii. Tektronix is represented in twenty-five overseas countries by qualified engineering organizations.

European and African countries, the countries of Lebanon and Turkey, please contact TEKTRONIX INTERNATIONAL A.G., Terrassenweg 1A, Zug, Switzerland, for the name of your local engineering representative.

Other Overseas areas, please write or cable directly to Tektronix, Inc., International Marketing Department, P. O. Box 500, Beaverton, Oregon, U.S.A. Cable: TEKTRONIX.

CIRCLE 107 ON READER-SERVICE CARD

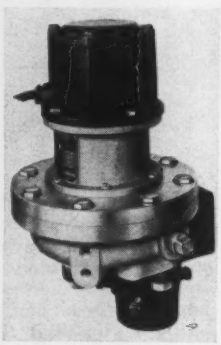
GENERAL PURPOSE RELAY



New MG Series low-cost General Purpose Relay comes in 1C (SPDT), 2C (DPDT) and 3C (3PDT), 2-amp rated contact arrangements and a variety of standard and special coil voltages and resistances. Operating power is 1.5 w for d-c relay and 2-3 volt-amp for a-c relay.—*Elgin Advance Relays Electronics Div., Elgin National Watch Co., 2435 N. Naomi St., Burbank, Calif.*

CIRCLE 300 ON READER-SERVICE CARD

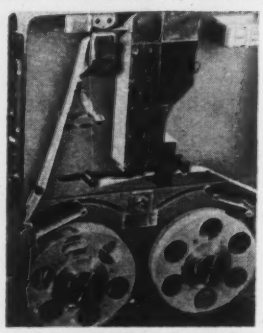
GAS DENSITY CELL



New Type 35 Gas Density Cell produces a differential pressure directly proportional to density. Combined with pressure differential across a primary device, this affords determination of mass flow of gas. Range is to 7.8 lb/cu ft.—*Foxboro Company, Foxboro, Mass.*

CIRCLE 301 ON READER-SERVICE CARD

TAPE RECORDER/READER



New Model ETR-7 Omni-Data Recorder and Omni-Data Reader are for coded paper tape which feature speeds in excess of 1,000 characters/sec, higher density recording, ability to read opaque, translucent and transparent tape interchangeably without modification of equipment, indefinitely long operating periods without adjustment. Information is stored on surface of paper.—*Omnitronics, Inc., 511 N. Broad St., Phila., Pa.*

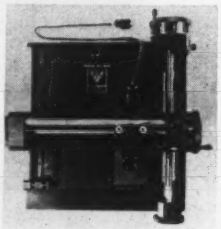
CIRCLE 302 ON READER-SERVICE CARD

SUPPLY

New Model ABC 30-0.3M 30 vdc/ 300 ma Power Supply features small size, capability and low price. Made portable, rack mounted, or chassis mounted. Bulletin 146-0026.—*Kepco, Inc., 131-38 Sanford Ave., Flushing 52, N. Y.*

CIRCLE 303 ON READER-SERVICE CARD

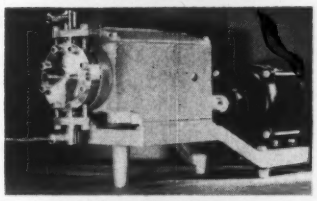
MICROMETER READER



New portable Micrometer Reader for reading charts, graphs, and film negatives or positives covers 5.5" x 6" area, has self-contained light source which projects cross-hair onto chart, eliminates parallax. Full scale accuracy of 0.0005" or less in one or both directions is optional. Bulletin.—*V. E. Kuster Co., Box 7038A, Long Beach 7, Calif.*

CIRCLE 304 ON READER-SERVICE CARD

METERED FLOW



New positive-displacement-type Pulsafeeder Microflo LS-30 line has metal diaphragm (which extends temperature range to 212°F and pressure range to 3000 psi) flow ranges to 780 cc/hr, stroke length of 3/8", piston size of ¼". Adjustable in increments of 1/1000th of maximum output.—*Lapp Insulator Co., Process Equipment Div., 129 Hall St., LeRoy, N. Y.*

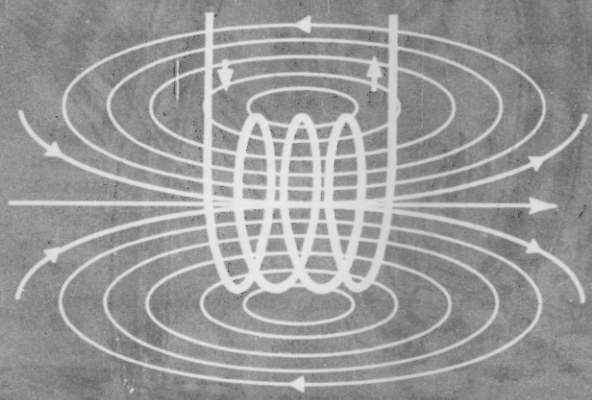
CIRCLE 305 ON READER-SERVICE CARD

VALVE POSITIONER/ACTUATOR

New invertible pneumatic force-balance Axial Positioner-(Model 7500)-and-Actuator combination provides installation of valve for direct or reverse action, with or without positioner. *Mason-Neilan Div. of Worthington Corp., Norwood, Mass.*

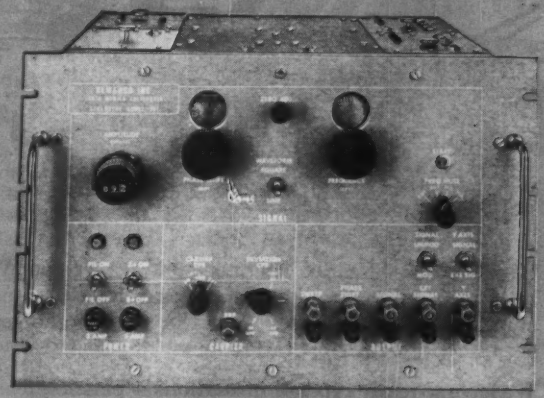
CIRCLE 306 ON READER-SERVICE CARD

FOR ACCURATE* CHECK OUT OF SERVO SYSTEMS...



REMANCO

SERVODYNE†
SERVO ANALYZER



*So Accurate, Servodyne exceeds its own tight specifications

Repeatability . . . Servodyne excels. It's all electronic — no mechanical devices. Rugged — and simple to maintain.

Wherever servo-mechanisms are used — in flight control, flight table, automated machinery, and other servo applications — Remanco's Servodyne Servo Analyzer provides a reliable means for system checkout. In practice, accuracy exceeds rigid factory standards prescribed for the unit. Featuring modular design for easy maintenance, the Servo Analyzer is rugged, simple to operate . . . For complete test and evaluation of AC servo systems . . . For frequency phase, and transient response tests of DC servos. Frequency ranges from .001 to 100 cps; sine or square wave outputs, entire range. Other servo analyzers designed and built to customers' specifications are available.

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We Thermo Electric Thermocouple Extension Wires are Rugged! You can run us through heat, moisture, mechanical abuse, even contaminants — we still give you longer life and accuracy in your temperature measuring systems!

We have so many types of insulations — plastics, fibers, metallic sheaths and armor — that you can choose exactly the right type to meet your applications. Our conductors are extra special too! We're drawn, calibrated and selected in our own wire mill to meet precise quality standards.

WRITE TODAY FOR YOUR WIRE CATALOG W–12

More than 18 pages of information on our whole family, including CERAMO® metal sheathed-ceramic insulated wire and THERMO-CABLE* — 6 to 56 pairs of matched conductors in one cable. Write Today!

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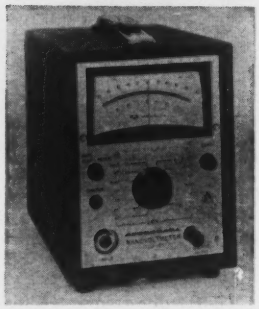
CIRCLE 109 ON READER-SERVICE CARD

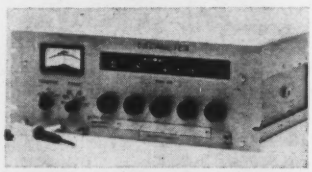
NANOVOLTMETER



New portable transistorized Nanovoltmeter features 13 full-scale d-c ranges of ± 0.1μ to ± 100μ, dissipates only 0.6 watts. Has built-in battery charger. Input resistance is 1 megohm on all ranges; source resistance can vary from 0 to 2000 ohms; accuracy is 2%.—*Astrodata, Inc.*, 240 *E. Palais Rd., Anaheim, Calif.*

CIRCLE 307 ON READER-SERVICE CARD

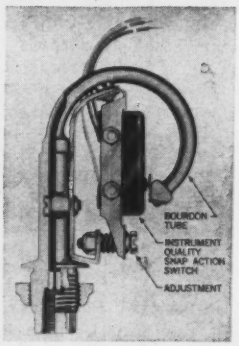
DECAMETERS



New Model 600 Series Decameters 5-digit precision differential instruments measure a-c voltage from 1 to 1000 v f.s. with 0.2% accuracy; resistances from 100 ohms to 10 megohms f.s. and d-c voltages with 0.1% accuracy. Fully floating and shielded from the power line. Have Zener diode supply stable to better than 0.001% for 10% line change.—*Auto-Data*, 943 *Turquoise, San Diego, Calif.*

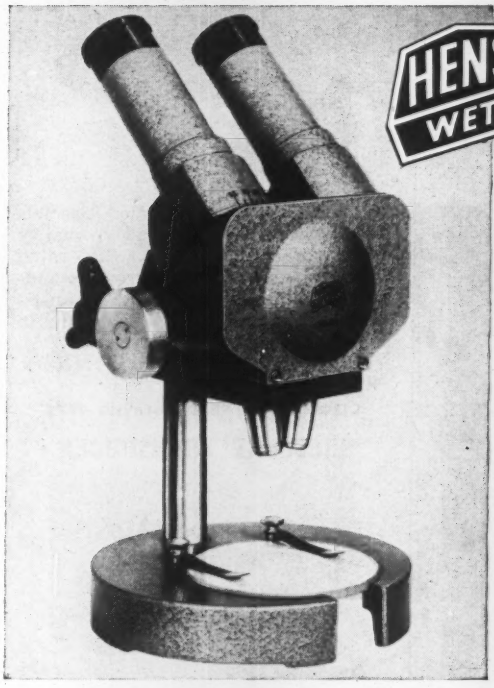
CIRCLE 308 ON READER-SERVICE CARD

PRESSURE SWITCHES



New Bourdon-tube Pressure Switches have five classes of adjustable range with choice of settings from 50 to 12,000 psi. Set and re-set accuracy is ± ½%, proof pressures are to 18,000 psi. Explosion-proof housings available.—*Barksdale Valves*, 5125 *Alcoa Ave., Los Angeles* 58, *Calif.*

CIRCLE 309 ON READER-SERVICE CARD



HENSOLDT WETZLAR

"DIAMAL" II STEREO-MICROSCOPE

3.3x to 80x

The high optical efficiency and compactness of this fine instrument make it ideal for the shop, inspection room or the laboratory.

The parallel inclined eye-pieces afford strainless three-dimensional vision. And its range of magnifications is exceptional in a stereoscopic instrument.

Interchangeable optical systems for magnifications from 3.3x to 80x are available. Also four different types of stands suitable for transmitted or reflected light, various reflected light illuminants, etc.

HENSOLDT QUALITY

The "Diamal" II is representative of the fine optical quality for which Hensoldt of West Germany has been noted since 1852.

MADE IN WEST GERMANY

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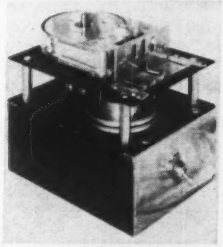
CIRCLE 110 ON READER-SERVICE CARD

MAGNETIC TAPE TRANSPORT



New Repeater Reel Unit instantly plays any one of several messages from 30 sec to 5½ min duration. Spliced tape forms continuous loop. —*Metric Processing Corp., 143 Roseland Ave., Caldwell, N.J.*

CIRCLE 310 ON READER-SERVICE CARD

FIBRE OPTICS CRT

New Fiber-optics Cathode Ray Tubes, a joint development of American Optical Co. and Sylvania Electric Products, Inc., print recording directly from tube face without use of conventional lenses and at speeds to 50 times faster. Available with electrostatic deflection and focus for experimentation, and electromagnetic deflection and focus for small spot size for utilization of high resolution. Active fiber optics area is 2¾" x ¼" composed of one-mil fibers on one-mil centers.—*American Optical Co., Southbridge, Mass.*

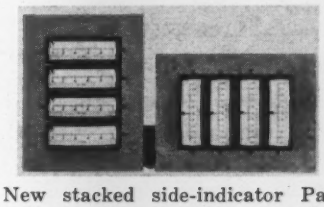
CIRCLE 311 ON READER-SERVICE CARD

DATA PROCESSOR

New RAMAC 305, Model 2 low-cost version random access data processing system can handle a typical job approx. 70% as fast as the RAMAC 305, Model 1. Basic system consists of 305 processor, 340 power supply, 323 card punch, 380 console, and 350 disc file; reads up to 80 and punches up to 50 cards/min; stores five-million alphanumeric characters; and processes program steps in 50 msec. —*International Business Machines Corp., Data Processing Div., 112 E. Post Rd., White Plains, N. Y.*

CIRCLE 312 ON READER-SERVICE CARD

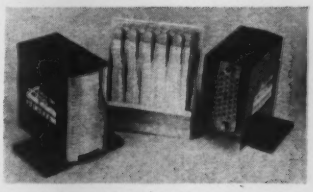
SIDE INDICATOR METERS



New stacked side-indicator Panel Meters available in all conventional ranges with a wide variety of different scales permit either horizontal or vertical mounting with zero at either end of scale or center. Internal illumination available.—*International Instruments, Inc., 88 Marsh Hill Rd., Orange, Conn.*

CIRCLE 313 ON READER-SERVICE CARD

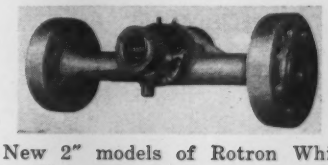
DIGITAL READ-WRITE HEAD



New Read-Write Head reads 16 tracks of digital information with two heads interlaced. Inductance is 4 mh for write head and 40 mh for read head. All 16 channels read within 1½ db of nominal amplitude.—*Applied Magnetics Corp., Box 368, Goleta, Calif.*

CIRCLE 314 ON READER-SERVICE CARD

HI-PRESS FLOWMETER



New 2" models of Rotron Whirl-Flo Flowmeter incorporate vortex-velocity principle of measurement, have pressure rating of 5000 psig. Model L2S-H is for liquid flow, Model G 25-H for gases. Adjustable internal bypass serves as calibrator in the field.—*Rotron Controls, Div. Rotron Mfg. Co., Inc., Woodstock, N. Y.*

CIRCLE 315 ON READER-SERVICE CARD

•MACHINING AND PROCESS CONTROL

•COUNTING

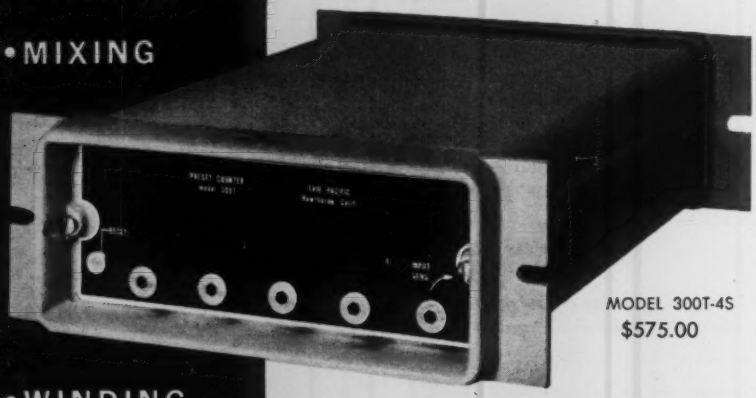
•BATCHING

•SORTING

•MIXING

NEW!

HIGH-SPEED, SOLID-STATE, PRESET COUNTER



MODEL 300T-4S
$575.00

•WINDING

•PACKAGING

...or any other physical process that can be electrically digitized.

The completely transistorized Model 300T industrial counter is rugged, dependable and low-cost control instrumentation that is ideal for every use requiring a preset counting device. Modular design minimizes maintenance time and steel construction permits mounting directly on controlled machine. Modules can be easily modified for special applications. The 300T is a truly remarkable instrument that deserves your serious consideration.

Send today for complete technical information.

SPECIFICATIONS

Speed: 6,000,000 counts per minute
Range: 1 to 9,999 standard. 5 to 8 decades available
Reset: Automatic, manual, local or external
Size: 3½″ high; 9½″ wide; 14″ deep (standard model)
Weight: Approx. 10 lbs.

Quality Where It Counts

ERIE Instrumentation.

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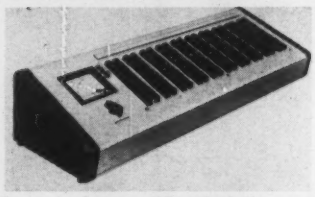
12932 S. Weber Way, Hawthorne, California
Phone: ORegon 8-5418

CIRCLE 111 ON READER-SERVICE CARD

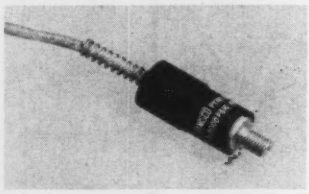
STATISTICS COMPUTER



New desk-top "Statistic" specialized Analog Computer for quality control work computes mean value with better than 2% accuracy, standard deviation with 1%. Transisterized, fully automatic. Bulletin 91436A.—*Boonshaft and Fuchs Inc., Hatboro Industrial Park, Hatboro, Pa.*

CIRCLE 316 ON READER-SERVICE CARD

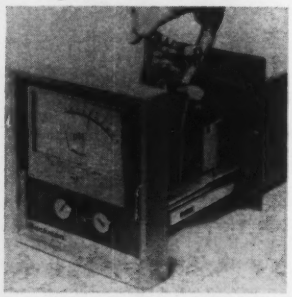
PRESSURE TRANSDUCER



New Model PT110 bonded-strain-gage Pressure Transducer features double-walled-cylinder design. Pressure medium is admitted to space between two concentric cylinders to expand outside cylinder and compress inside cylinder. Pair of circumferentially-wound strain gages bonded on inside of inner cylinder wall and another pair on outside of outer cylinder wall form a complete four-active-arm Wheatstone bridge.—*Dynisco, Div. of American Brake Shoe Co., Cambridge, Mass.*

CIRCLE 317 ON READER-SERVICE CARD

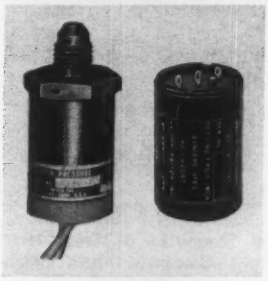
pH ANALYZER



New solid-state Model J Industrial pH Analyzer System includes analyzer, electrodes, and electrode mounting chambers. Analyzer employs a-c stabilized amplifier with stability of 0.01 pH/24 hrs over −20° to +122°F ambient temperature range. Output accuracy and meter sensitivity is ±0.02 pH for full 0-14 pH range. Available with milliampere and/or millivolt output for use with any potentiometric or current-type recorder.—*Beckman Scientific and Process Instruments Div., 2500 Harbor Blvd., Fullerton, Calif.*

CIRCLE 318 ON READER-SERVICE CARD

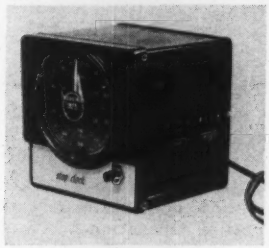
MINI PRESSURE SWITCHES



New Type 1100 Miniature Pressure switches are made with or without pressure port and with solder terminals, potted leads, or electrical connector. Factory adjusted to pressure settings from 10 to 500 psig with proof pressure of 750 psig.—*Haydon Switch, Inc., Waterbury 20, Conn.*

CIRCLE 319 ON READER-SERVICE CARD

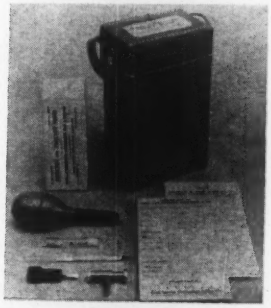
AUTOMATIC STOP CLOCK



New Automatic Stop Clock measures time intervals down to 1/100 sec. Can be started, stopped, and reset by remote means and features unique cone clutch which engages pointer mechanism with synchronous motor.—*Industrial Timer Corp., 1407 McCarter Hwy., Newark, N. J.*

CIRCLE 320 ON READER-SERVICE CARD

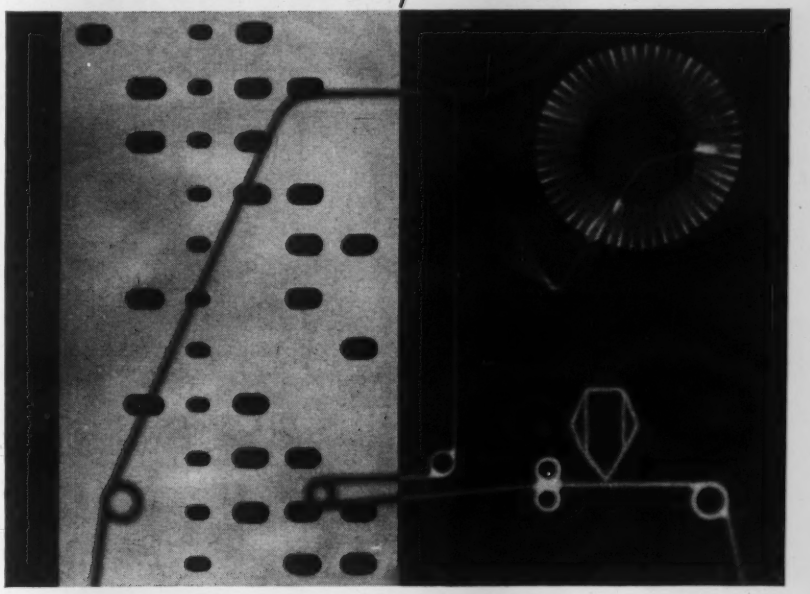
TOXIC CONCENTRATIONS



New portable Halogenated Hydrocarbon Detector measures toxic concentrations of trichloroethylene, ethyl chloride, methyl bromide, etc. Consists of a reactor tube and a detector tube, joined together. Sample of air is drawn through proper detecting unit by aspirator bulb assembly. Released halogen gas reacts with chemical in detector tube to form a length-of-stain indication. Calibration chart provides quick reading.—*Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh 8, Pa.*

CIRCLE 321 ON READER-SERVICE CARD

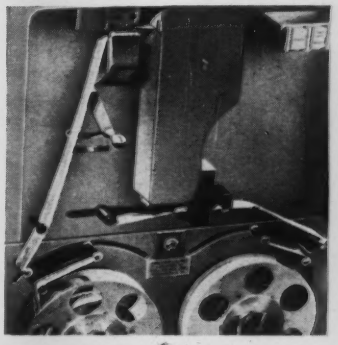
omni-data ...a new generation in paper-tape equipment



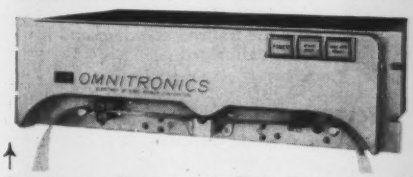
- **High-speed electrostatic paper-tape recorder replaces mechanical punches**
- **Reflected-light reader accommodates all tapes—punched or recorded, opaque or transparent**

OMNI-DATA, a new line of equipment based on non-mechanical, non-impact reading and recording techniques, brings a new order of reliability, speed, and operating life to the application of coded paper tape.

OMNI-DATA combines two exclusive Omnitronics advances: Visible recorded code presentation, rather than punched holes in the tape, and chopped-reflected-light reading, both resulting in new levels of performance and the elimination of the bothersome chads of punched tape.



Visible recorded data issues from OMNI-DATA recorder at speeds up to 600 characters a second at 10 characters to the inch. Even higher recording and reading speeds, as well as greater packing density, are possible.



Omnitronics Photoelectric Tape Reader, a part of the OMNI-DATA system, reads any kind of tape (OMNI-DATA or punched, opaque or transparent) interchangeably without adjustment.

Learn the exciting details about OMNI-DATA recorders, readers, and reelers. Write for full information and the name of your nearest Omnitronics representative.

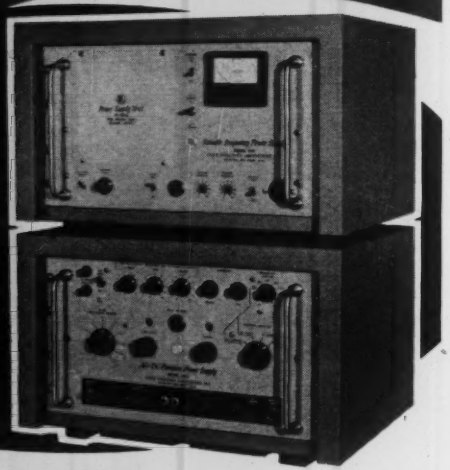
OMNITRONICS, INC.
Subsidiary of Borg-Warner Corporation
Dept. ICS-11, 511 N. Broad St., Philadelphia 23, Pa.

See us in Booth B-16, Eastern Joint Computer Conf., Dec. 12-14, Wash., D.C.

CIRCLE 112 ON READER-SERVICE CARD

AC-DC Precision Power Supply

Model 2120 PROVIDES Variable Voltage, Current & Frequency



RANGES

VOLTAGE: 0 to 1500 Volts AC and DC
CURRENT: 0 to 30 Amperes AC and DC
FREQUENCY: 50 C/S to 20 Kc/S

Rated output varies from 30 to 100 VA depending on output frequency selected. In addition to continuous coverage, fixed settings of 50, 60, 400, 800, 1000, 1600 and 2400 c/s are provided. Regulation is ±0.1% for 5% line or 25% load change; short term stability is better than ±.03%. Resolution of output adjustment is ±.01% for voltage and current. Housed in two cabinets for maximum utility, the Model 2120 is priced at $2950.

INSTRUMENT CALIBRATION

The Model 2120 is particularly suited for use with a separate monitoring system to standardize and calibrate high accuracy digital, indicating and recording instruments. Its distortion levels meet the most critical instrument calibration requirements.

A typical, highly accurate calibration set-up using an RFL Model 1605A AC-DC transfer standard with the Model 2120 mounted on a wheeled carrier is illustrated. Protective circuits safeguard both the transfer standard and instrument being calibrated.

Performance is rigidly guaranteed. Price is net, f.o.b. Boonton, N.J. and subject to change without notice.

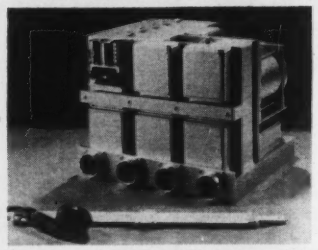
SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U.S.A.

CIRCLE 113 ON READER-SERVICE CARD

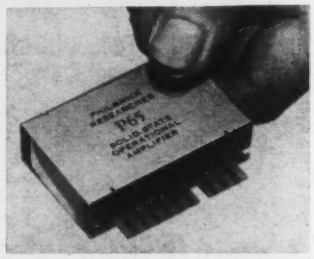
MINI DIGITAL COMPUTER



New Model L-70 Miniature flight-guidance Computer has gas-bearing memory drum utilizing thin film of helium as bearing. Features include high reliability, minimum power requirement due to welded-circuitry construction.—*General Precision, Inc., Librascope Div., Glendale 1, Calif.*

CIRCLE 322 ON READER-SERVICE CARD

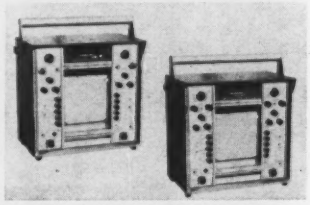
OPERATIONAL AMPLIFIER



New P65 solid-state miniaturized Differential Operational Amplifier contains no choppers or modulators, has direct-coupled input circuit with differential input range of ±10 v and common mode rejection of about 10,000 to 1. With d-c open-loop gain at 20,000 and unity gain crossover occuring at 1.6 mcps, it maintains full output to 10 kcps. Output range is ±1.1 ma at ±11 v; power requirements are ±15 v at ±4 ma.—*George A. Philbrick Researches, Inc., 127 Clarendon St., Boston 16, Mass.*

CIRCLE 323 ON READER-SERVICE CARD

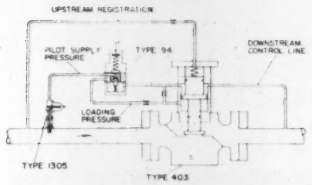
PORTABLE RECORDERS



New Model 322 DC Coupling and Model 321 Carrier portable 2-channel Direct Writers use heat-sensitive Permapaper® charts with 50-mm wide channels for inkless rectangular-coordinate recordings of variables in the d-c-to-125-cps frequency range. Coupling recorder with medium gain amplifier has sensitivity ranges of 10, 20, 50, 100, 200, 500 mv/division and 1, 2, 5 and 10 v/division. Carrier provides 2400-cps carrier frequency and 4.5 excitation voltage.—*Sanborn Co., Industrial Div., 175 Wyman St., Waltham 54, Mass.*

CIRCLE 324 ON READER-SERVICE CARD

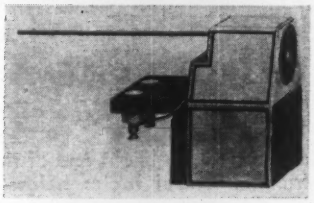
GAS REGULATOR



New installation for Type 403 high-pressure Gas Regulator has a Series-1305 anti-freeze regulator installed in pilot loading line ahead of pilot, projecting into warm upstream gas flow in main line. Pilot loading gas is maintained at temperature high enough to prevent pilot freezing. —*Fisher Governor Co., Marshalltown, Iowa.*

CIRCLE 325 ON READER-SERVICE CARD

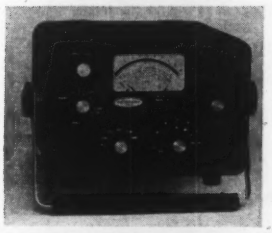
MINI SOLENOID ACTUATOR



New miniature Solenoid Actuator for microwave attenuation features operating time of 0.002 sec, pin movement of approx. 0.1", and average operating power of 2 w. Mounts directly on microwave plumbing. Life expectancy is in excess of 10 million cycles when completely withdrawing pins from cavity in less than 1.9 msec.—*Hathaway Denver*, 5800 *E. Jewell Ave., Denver* 22, *Colo.*

CIRCLE 326 ON READER-SERVICE CARD

VOLTMETER



New Model R-21 Voltmeter measures a-c and d-c voltages from 1 mv to 1000 v full scale in 14 ranges, and midscale resistances from 10 ohms to 10 megohms in 7 decade ranges. "DC Distend" feature allows upper 10% or 1% of any d-c-volt range to be expanded over full meter scale.—*Hathaway Denver*, 5800 *E. Jewell Ave., Denver* 22, *Colo.*

CIRCLE 327 ON READER-SERVICE CARD

For More Information on Products Listed Please Circle the Corresponding Number on Reader-Service Card

COLD END LEAD BREAKAGE ELIMINATED

in MgO thermocouples

conax®

T-3 TERMINATION

Optimum MgO thermocouple performance (and ultimate economy) requires that no phase of design or manufacture be overlooked. Conax demonstrates this fact from tip to termination. The T-3 termination's exclusive strain harness design takes all the stresses on the lead wires away from the thermocouple wires. Conax builds in additional value by electrically welding the junctions, thus eliminating corroding and contaminating fluxes that shorten thermocouple life. These are just a few of the facts that make Conax the truly economical thermocouple buy.

TAKE A TIP – GET ALL THE FACTS ON:

Con-O-Clad . . . ask for catalog 300

Thermocouple Assemblies . . . ask for catalog 1890

Electrode Glands . . . ask for catalog 960

Standard "24 Hour Delivery" thermocouples . . . ask for catalog 2400

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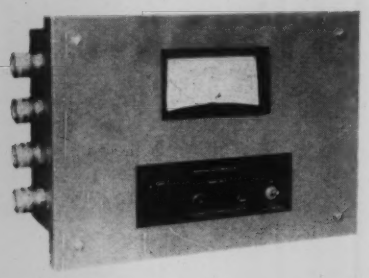
CIRCLE 114 ON READER-SERVICE CARD

new

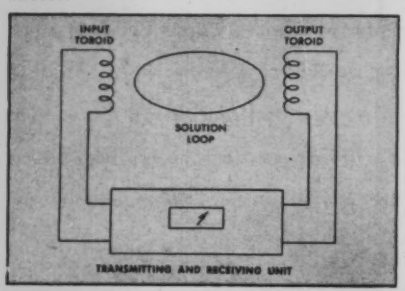
ELECTRODELESS CONDUCTIVITY MEASURING SYSTEM

Improved performance at lower cost



The Type RS electrodeless conductivity measuring system was first introduced by Industrial Instruments Inc. in 1957. Since that time many applications formerly difficult, if not impossible, for conventional electrode systems have been successfully instrumented by the system. This new system supplements standard techniques (Wheatstone Bridge circuit and electrodes in solution) and is recommended for conditions where the presence of fibers tends to clog conventional conductivity cells, or for abrasive slurries, hot highly conductive solutions, or extremely corrosive solutions.

A continued program of development has resulted in a number of improvements in both the cell, and the transmitting and receiving units. These design changes have also lowered the initial cost of the equipment, permitting its use in areas where cost has previously been a limiting factor.



The single electronic package contains both transmitter and receiver and incorporates a direct-reading meter. The instrument provides a stable 0-10 mv DC output for operating a standard potentiometer recorder or recorder-controller. Available to meet explosion-proof requirements.

Industrial Instruments

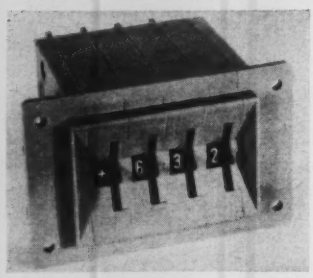
Write for complete details

Industrial Instruments Inc.

89 Commerce Road Cedar Grove Essex County N J

CIRCLE 115 ON READER-SERVICE CARD

THUMBWHEEL SWITCH



New Decaswitch low-cost digital Thumbwheel Switch is available in single-pole/10-position, single-pole/11-position, plus/minus, binary and 2-pole, 5-position models. Gold-plated switch contacts feature low resistance.—*Siegler Corp., Magnetic Amplifiers Div., 632 Tinton Ave., Bronx 55, N. Y.*

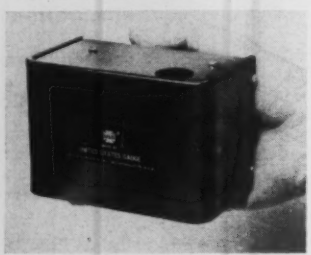
CIRCLE 328 ON READER-SERVICE CARD

DATA SYSTEM

New Mobidac portable Mobile Data Acquisition System accepts 48 input data channels directly from transducers at full-scale levels at low millivolts. Inputs are multiplexed and digitized into binary or BCD codes and recorded on magnetic tape. Mobidac consists of Model LL-1 low-level multiplexer, ADC-1B analog-to-digital converter, logic/control unit, and tape transport.—*Systems Engineering Laboratories, Inc., 4066 NE. Fifth Ave., Fort Lauderdale, Fla.*

CIRCLE 329 ON READER-SERVICE CARD

LEVEL SAFETY SWITCH



New Water Level Safety Switch prevents pump damage due to insufficient liquid at the source, or when pump loses its prime, Mounts on pump discharge line and is series-connected with pump motor power supply. Disconnects pump motor, if after predetermined period pump discharge is not at specified pressure level.—*United States Gauge Div., American Machine & Metals, Inc., Sellersville, Pa.*

CIRCLE 330 ON READER-SERVICE CARD

READERS & ADVERTISERS

have a lot to look forward to in future issues of

INSTRUMENTS and CONTROL SYSTEMS

Each issue will highlight one of the instrument-control topics below—

Temperature Measurement and Control

Telemetering

Recording

System and Data Instrumentation

Process Instrumentation

Analytical Instrumentation and Stream Control

Current and Voltage Control

Electrical Measurement

Pressure Instrumentation

Programming & Timing

Flow Measurement and Control

Strain, Force, Tension and Weight

ADVERTISERS will share in the resultant reader enthusiasm.

FOR AD SPACE DETAILS—call your nearest district office—see addresses on page 1964.

A. D. JONES OPTICAL WORKS

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People usually associate Optics with **glass** only. The following materials, successfully processed here by sawing, grinding and polishing or drilling are of value to designers, engineers and manufacturers. Most materials are supplied by our customers for their orders.

ALUMINA
ALUMINUM
ARSENIC TRISULPHIDE
BARIUM TITANATE
BRASS
CALCIUM TUNGSTATE
CARBORUNDUM
CERAMIC
COBALT FERRITE
COPPER
CORNING 707
CORNING 7052
FERRITE
FERROX
FLUORIDE, CALCIUM
FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM FERRITE
MAGNESIUM STANIDE
NICKEL OXIDE
NIOBIUM
PLATINUM
POTASSIUM BROMIDE
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SAPPHIRE
SILICON
SODIUM CHLORIDE
STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
VYCOR
VANADIUM
X-RAY LEAD GLASS

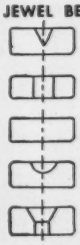
CIRCLE 116 ON READER-SERVICE CARD

SAPPHIRE

WEAR PARTS

ELECTRICAL INSULATORS

JEWEL BEARING TYPES



Jewel Bearings - Wear Parts

If you need a surface finish polished to 1 RMS and/or a material of extreme hardness, high dielectric strength, resistance to heat and corrosion, SAPPHIRE could be the answer to your problem.

We design and furnish jewel bearing assemblies, controlled within critical tolerances, for direct installation in your product.

Ask for our 28-page Design Data and Applications Manual No. 5A on Jewel Bearings and other Precision Sapphire Products.

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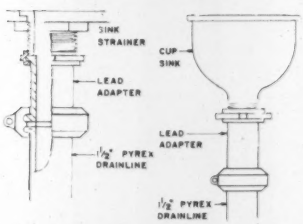
CIRCLE 117 ON READER-SERVICE CARD

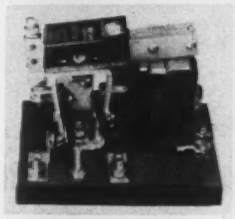
SINK ADAPTER



New lead-tail-piece Adapter permits coupling of lead chemical sink strainers or cup sinks to 1½" Pyrex drain pipes.—*Chem Flow Corp.*, 117 *Paterson Ave., Little Falls, N. J.*

CIRCLE 331 ON READER-SERVICE CARD

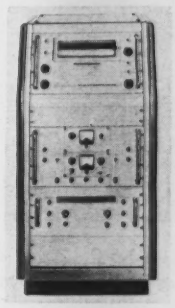
RELAYS AND CONTACTORS



Four new low-cost 30-amp Relays and Contactors suited for electric heating and lighting. Rated at 30 amp, 250 vac. Bulletin 703.—*Automatic Switch Co., Florham Park, N. J.*

CIRCLE 333 ON READER-SERVICE CARD

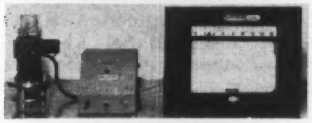
ANTENNA CONTOUR PLOTTER



New Model ACP 1 Antenna Coutour Plotter, maps Φ, Θ, and amplitude coordinates in IRIG format. In addition, antenna patterns can be recorded. Plots 5" x 10" or 10" x 20" graphs.—*Scientific - Atlanta, Inc.*, 2162 *Piedmont Rd., N. E., Atlanta 9, Ga.*

CIRCLE 335 ON READER-SERVICE CARD

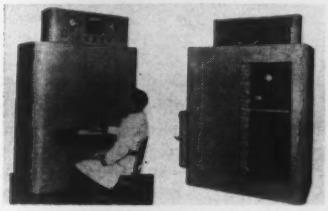
RECORDING MICROMETER



New Electronic Micrometer displays measurements exact to 10-millionths inch on 5-digit counter and automatically plots values on chart recorder. Readings are taken on one-minute or other pre-selected time cycle. Typical use: dilatometer measurements of material expansions at elevated temperatures.—*J. W. Dice Co., Englewood, N. J.*

CIRCLE 332 ON READER-SERVICE CARD

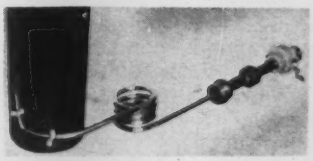
PRESSURE LAB UNIT



New Self-Barricaded High-Pressure Laboratory Unit is for research to 5,000 psi at 650°F. Includes pressure vessels, valving, tubing, and instrumentation.—*Autoclave Engineers, Inc.*, 2943 *W. 22 St., Erie, Pa.*

CIRCLE 334 ON READER-SERVICE CARD

MINI T/C ASSEMBLY



New all-stainless-steel Trinox Thermocouple Assembly has small pad welded at the hot junction for temperature sensing of large-diameter heater tubes. Coils allow for expansion and contraction of heater tubes. —*Trinity Equipment Corp., Cortland, N. Y.*

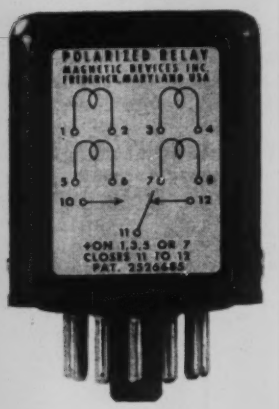
CIRCLE 336 ON READER-SERVICE CARD

For

SERVO MECHANISM

features of MDI POLARIZED RELAYS are preferred*

Actual size



MULTIPLE COILS — 1, 2, 3 or 4 coils for multiple input operation

HIGH SPEED — 1 millisecond

CONTACT ARRANGEMENT — side-stable, magnetic latching; center-off, three position; biased, two position

RUGGED — designed to withstand environmental conditions of MIL-E-16400, shock pulses to 125 g and vibration to 500 CPS without damage.

* as determined by survey of representative sample of 32,916 engineers.

Write for descriptive literature.

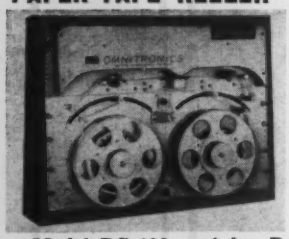
MAGNETIC DEVICES, INC.

Dept. 5 712 East Street

Frederick, Maryland

CIRCLE 118 ON READER-SERVICE CARD

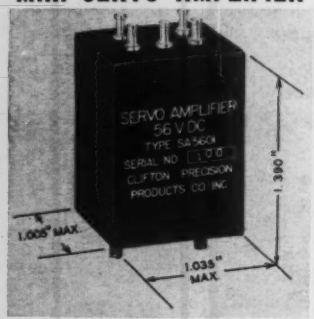
PAPER-TAPE REELER



New Model RS-400 modular Reeler for paper-tape speeds up to 60 ips with reels up to 10½" dia handles all types of tapes, including Omni-Data recorded tape. Bulletin RS-400.—*Omnitronics, Inc., Subs. of Borg-Warner Corp., 511 N. Broad St., Phila. 23, Pa.*

CIRCLE 337 ON READER-SERVICE CARD

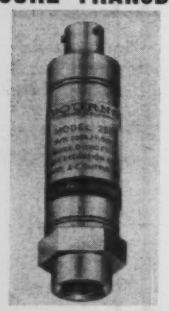
MINI SERVO AMPLIFIER



New SA 5601 5-watt Servo Amplifier built around a d-c amplifier with high frequency cutoff above 30 kcps provides uniform response over full operating range. Voltage gain is 54 ±1 db from −55° to 125°C with a 10 kilohm input resistor. 1.390" x 1.035" x 1.005".—*Clifton Precision Products Co., Inc., 5050 State Rd., Drexel Hill, Pa.*

CIRCLE 338 ON READER-SERVICE CARD

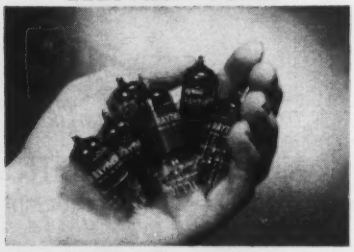
PRESSURE TRANSDUCER



New Pressure Transducer Model 2521 with diaphragm-actuated unbonded-strain-gage elements features high mv/v output, stainless-steel construction. Specifications include: pressure range—0-5 to 0-5000 psia; linearity and hysteresis (combined)—less than ±0.25%; zero balance—±1% of full-scale output; thermal zero shift—±0.005%/°F. Bulletin.—*Bourns, Inc., Instrument Div., 6135 Magnolia Ave., Riverside, Calif.*

CIRCLE 339 ON READER-SERVICE CARD

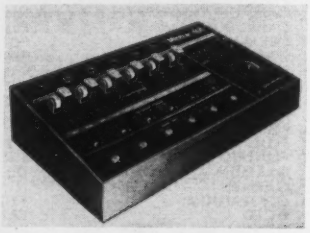
ELECTRON TUBES



New line of Industrial Receiving Tubes (formerly manufactured by CBS Electronics) comprises 6 types, 7728 through 7733, features precisely made and fitted parts for low noise and microphonims, gold-plated pins and rugged coil heater.—*Raytheon Co., Industrial Components Div., 55 Chapel St., Newton 58, Mass.*

CIRCLE 340 ON READER-SERVICE CARD

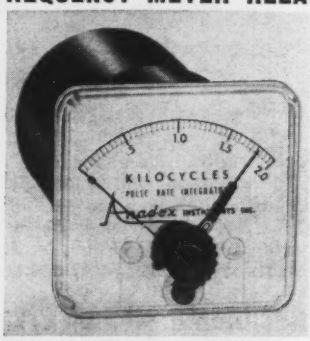
COMPUTER SIMULATOR



New Minivac 601 electronic Digital Computer Simulator requires no previous knowledge of mathematics or electronics. Six comprehensive manuals explain functioning and use.—*Scientific Development Corp., 372 Main St., Watertown, Mass.*

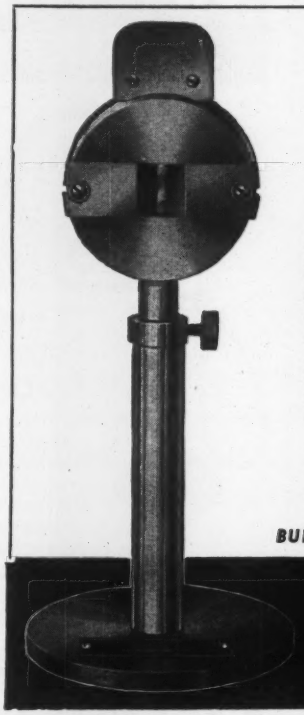
CIRCLE 341 ON READER-SERVICE CARD

FREQUENCY METER RELAY



New Frequency Meter Relay combines a Model PI-100 Anadex frequency converter with meter relays by Assembly Products. Available as continuous reading type where meter continues to read past set-point to full scale, or as locking type where meter stops reading at set-point and will not re-set itself until frequency signal returns to set-point. Input sensitivity is 10 mv rms, accuracy is 1%. Standard full-scale frequencies range is from 50 kc to 50 cps.—*Anadex Instruments, Inc., 14734 Arminta St., Van Nuys, Calif.*

CIRCLE 342 ON READER-SERVICE CARD



EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

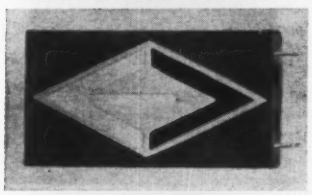
THE EPPLEY LABORATORY, INC.

SCIENTIFIC INSTRUMENTS

NEWPORT, RHODE ISLAND, U. S. A.

CIRCLE 119 ON READER-SERVICE CARD

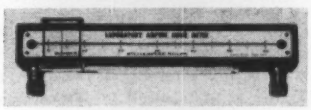
ELECTRONIC COUNTER



New Vector 8001 transistorized miniature Universal Counter provides settable count-controlled output impulse on each tenth input pulse. Operates at −6 to −10 vdc, has frequency of 10-30,000 cps, and input trigger pulse and output pulse of 0.5 to 1.0 μsec.—*Vector Mfg. Co., Inc., Commercial and Industrial Div., Dept. I-5, Southampton, Pa.*

CIRCLE 343 ON READER-SERVICE CARD

LAB AMP-HOUR METER



New direct-reading laboratory Ampere-hour Meter, an electrochemical device to measure current vs time, has 6" active scale and slide rule type cursor. Normal accuracy is 2%; higher accuracy available.—*Curtis Instruments, Inc., 45 Kisco Ave., Mount Kisco, N. Y.*

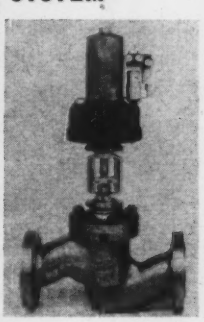
CIRCLE 344 ON READER-SERVICE CARD

POWER SUPPLY

New Model PS/200/3.5 dual regulated chopper-stabilized Power Supply provides simultaneous outputs of 0-200 ma at both −300 and +300 vdc from 117-vac input.—*Embree Electronics Corp., 993 Farmington Ave., West Hartford, Conn.*

CIRCLE 345 ON READER-SERVICE CARD

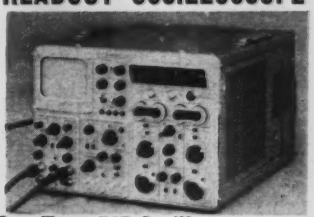
ELECTROHYDRAULIC VALVE SYSTEM



New line of high-precision Electrohydraulic Valves with integral electronic control systems and associated transducers responds to 100 cps. Controllers were developed in conjunction with Micro Gee Products, Inc., of Culver City, Calif., an affiliated concern.—*Security Valve Co., 909 El Centro St., South Pasadena, Calif.*

CIRCLE 346 ON READER-SERVICE CARD

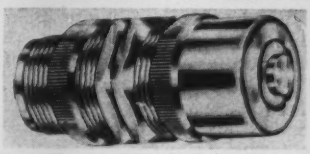
READOUT OSCILLOSCOPE



New Type 567 Oscilloscope presents analog display on its 5" CRT with digital readout on automatic computing programmer which features positionable measurement reference zones, automatic normalization, zone intensity markers, etc.—*Tektronix, Inc., Box 500, Beaverton, Ore.*

CIRCLE 347 ON READER-SERVICE CARD

DUAL-PURPOSE TRANSDUCER

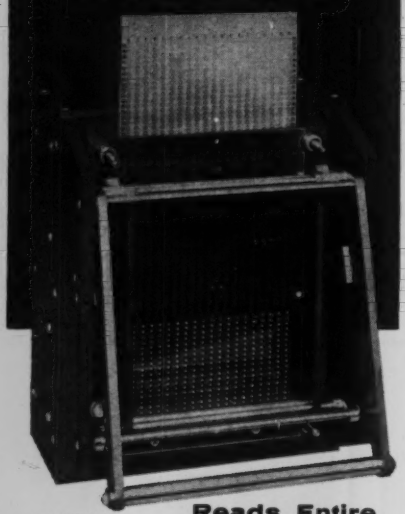


New Type PR-9262 dual-purpose Transducer can either detect or excite vibrations without contacting even magnetically non-conductive object to be tested. Also permits pulsating-phenomena investigation.—*Korfund Co., Inc., Acoustics and Insts. Div., 355 Cantiague Rd., Westbury, L. I., N. Y.*

CIRCLE 348 ON READER-SERVICE CARD

TAURUS

PUNCHED CARD SENSORS



K-1000 **Reads Entire Punched Card Statically**

FOR

Simple Switching Using Standard Punched Cards

This Taurus Punched Card Sensor, with 1000 switches, is programmed by a special Taurus card made of mylar.*

Each hole position has a corresponding closed switch, and each unpunched hole position has a corresponding open switch when the Sensor is actuated. Used for Automatic Test Equipment and other automation devices.

Taurus also produces a complete line of Standoff and Feedthru Terminals insulated with Teflon*.

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*REG. T.M. OF E.I. DUPONT

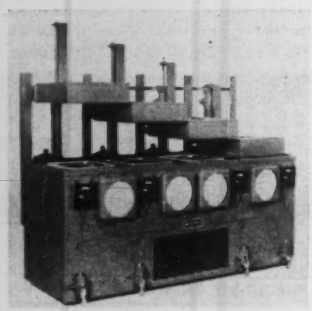
CIRCLE 120 ON READER-SERVICE CARD

WEIGHING SYSTEM

New Dynabatch eleven-scale, 43-ingredient automatic accumulative Weighing System for solids and liquids features digital indication of weights in batching, digital indication + pre-set weighing accuracy of each ingredient as added. Lifetime scale accuracy is 0.025%, total system accuracy 1/10 of 1%.—*Dynametrics Corp., Northwest Industrial Park, Burlington, Mass.*

CIRCLE 349 ON READER-SERVICE CARD

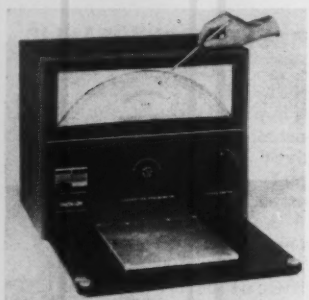
MULTIPLE TESTING CHAMBER



New Model SV-4-100-HC Temperature Test Cabinet contains 4 individual chambers, each with adjustable temperature range −100° to +400°F. Each stainless-steel liquid-tight chamber measures 14" x 14" x 14". Four components can be tested simultaneously at difference temperatures. Capacity is 500 BTU/hr at −100°F; lids can raise 100 lb by foot-controlled air cylinders.—*Cincinnati Sub Zero Products, 3932 Reading Rd., Cincinnati 29, Ohio.*

CIRCLE 350 ON READER-SERVICE CARD

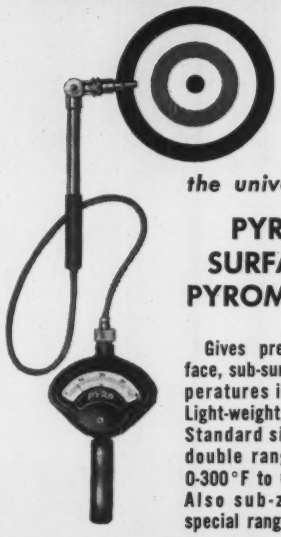
ABSORPTION DYNAMOMETER



New 1200 Series Absorption Dynamometer has special hysteresis brake to reduce starting torque, improve high-speed performance; features automatic transfer of torque ranges through progressive spring loading system.—*John Chatillon & Sons, 85 Cliff St., New York 38, N. Y.*

CIRCLE 351 ON READER-SERVICE CARD

UNEXCELLED ACCURACY



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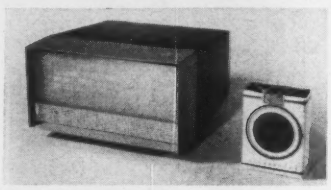
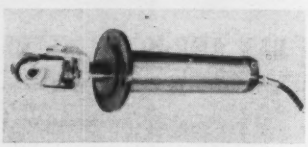
AN/DIG CONVERTER



New Model 101 analog-to-digital Converter features individual channel digitizing without multiplexing, 0.5% accuracy, ½ μsec conversion time, visual display of two binary-coded decimals.—*General Data Corp., 11602 Ninth St., Garden Grove, Calif.*

CIRCLE 352 ON READER-SERVICE CARD

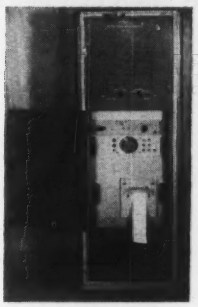
DISPLACEMENT TRANSDUCER



New Model 6020-B Displacement Transducer utilizes differential transformer with linear range displacement of ± 0.500", features built-in mechanical zero adjustment, sealed but accessible range adjust; dual stainless-steel guide shafts, self-lubricated brass bearings.—*Automatic Timing & Controls, Inc., King of Prussia, Pa.*

CIRCLE 353 ON READER-SERVICE CARD

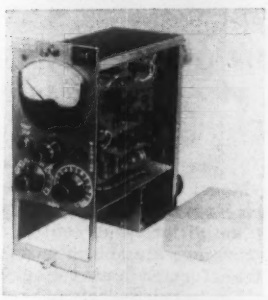
VOLTAGE INTEGRATOR



New multi-channel Voltage Integrator system sequentially measures any number of channels of analog information, converts data into digital form, prints out summed decimal digits after pre-set specified time. Time and channel data can be in numeric or alpha-numeric form. Sampling rate is one channel/sec.—*Harvey-Wells Electronics, Inc.*, 14 *Huron Dr., Natick, Mass.*

CIRCLE 354 ON READER-SERVICE CARD

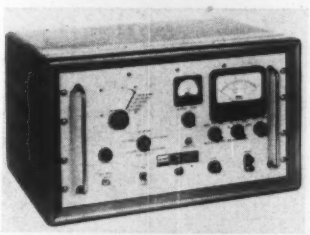
VIBRATION MONITOR



New transistorized portable Vibration Monitor detect and measures vibration amplitudes over 10-to-1000 cps frequency range. 8¾" x 3⅝" x 7½", weight 4 lb.—*Lehigh Valley Electronics, Inc., Allentown, Pa.*

CIRCLE 355 ON READER-SERVICE CARD

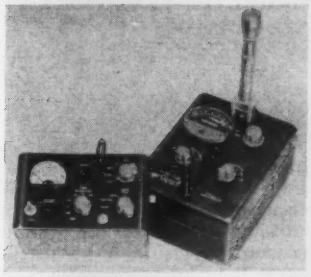
FM DEVIATION METER



New Model 400 FM Deviation Meter reads carrier frequency range directly within ±0.5% from 20 to 1000 Mc. Essentially a broadband FM receiver with ultra-linear discriminator, and accurate readout, deviation is indicated by a linear voltmeter. Has five peak deviation ranges from ±10, to ±1000 kc. Resolution in the 10-kc range is 100 cps.—*Advanced Measurement Instruments, Inc.*, 109 *Dover St., Somerville* 44, *Mass.*

CIRCLE 356 ON READER-SERVICE CARD

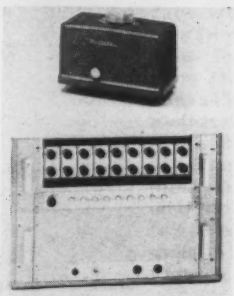
IMPACT NOISE ANALYZER



New Type 1556 B Impact Noise Analyzer measures peak value of pulse whose duration is only a few tens of μsecs, stored, and shown on meter. New push button simplifies resetting. Connected to output of sound-level meter, analyzer evaluates characteristics of impact-type sounds. —*General Radio Co., West Concord, Mass.*

CIRCLE 357 ON READER-SERVICE CARD

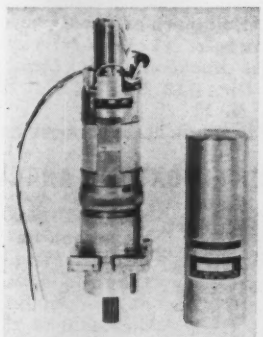
AUTOMATIC CHECKWEIGHER



New line of Automatic Electronic Balances for check weighing, sorting, statistical evaluation, and production control weigh low-weight-range objects. Seven different models available with 1-to-1000 gr capacities. Sensitivity is 0.05%; weighing speed up to 10,000/hr.—*Mettler Instrument Corp., Box* 100, *Princeton, N. J.*

CIRCLE 358 ON READER-SERVICE CARD

TORQUE UNIT



New permanent-magnet dc motor with planetary gear reducer and d-c rate tachometer produces torques in excess of 100 in-lb through speed range of 1 to 15 rpm. Feedback is 8 vdc per 1000 rpm.—*Globe Industries, Inc.*, 1784 *Stanley Ave., Dayton* 4, *Ohio.*

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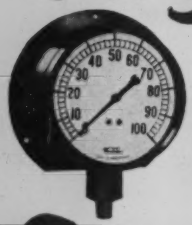

also for tough services, but less severe than the conditions served by the "Mastergauge"

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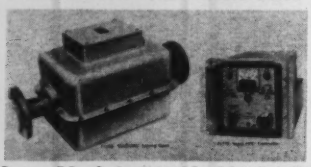
CIRCLE 123 ON READER-SERVICE CARD

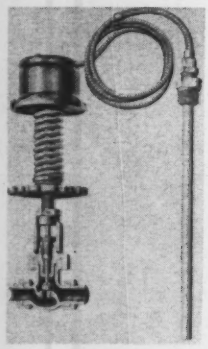
MAGNETIC FLOWMETER



New Model 712N MAG-PIPE® Electromagnetic Flowmeter provides output signal of 1-5 ma dc which can be transmitted with ½% accuracy up to 10,000 ft to miniature receivers or controllers. Ideal for viscous liquids and suspensions, for low velocities, and electrical conductivities as low as distilled water. Bulletin 98418.—*Taylor Instrument Companies, Rochester* 1, *N. Y.*

CIRCLE 360 ON READER-SERVICE CARD

TEMPERATURE REGULATOR



New Type T2 Temperature Regulator allows low-cost temperature control of small loads with pressure differentials of less than 3 psi. Single-seat construction and stainless-steel trim provide tight positive shut-off.—*Spence Engineering Co., Inc., Walden* 2, *N. Y.*

CIRCLE 361 ON READER-SERVICE CARD

COMPUTER OVERLAP

New "Processing Overlap" feature enables IBM 1401 computer to perform its computations simultaneously with a wide range of input/output functions increasing overall job speeds by as much as 20%. Although processing still must be interrupted for actual data transfer, computing can now overlap much of remainder of the input/output cycle.—*International Business Machines Corp., Data Processing Div., 112 E. Post Rd., White Plains, N. Y.*

CIRCLE 362 ON READER-SERVICE CARD

DISSOLVED OXYGEN ANALYZER

New DO-100 electromechanical and direct-acting Continuous Dissolved-oxygen Analyzer indicates 0 to 25 or 0 to 250 parts per billion and/or records on multivolt type. Readings are accurate to ±5% full scale.—*Wallace & Tiernan, Inc., 25 Main St., Belleville* 9, *N. J.*

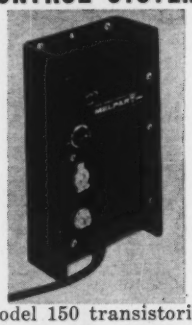
CIRCLE 363 ON READER-SERVICE CARD

LINEAR ACCELEROMETERS

New Linear Accelerometers feature fail-safe self-test circuit which checks response of all mechanical, hydraulic, and electronic systems that accept and respond to its output.—*Dynamic Measurements Co., 106 Terwood Rd., Willow Grove, Pa.*

CIRCLE 364 ON READER-SERVICE CARD

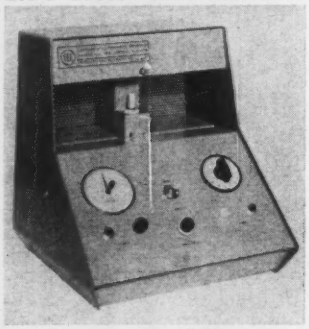
PHOTOELECTRIC CONTROL SYSTEM



New Model 150 transistorized Photoelectric Control Unit contains power supply, amplifier, and control relay in one compact aluminum case. Step-down transformer and voltage-doubler rectifier provide electrical requirements of corresponding readers. Main feature is high reliability.—*Melpar, Inc, Subs. of Westinghouse Air Brake Co., 3000 Arlington Blvd, Falls Church, Va.*

CIRCLE 365 ON READER-SERVICE CARD

SOLIDS MOISTURE ANALYZER



New Type 26-320 Solids Moisture Analyzer utilizes the Keidel electrolytic-cell principle. Accuracy is ±5 μgr down to 10 μgr, or 2% of final reading; sensitivity is 0.1 μgr. Dynamic range is 0.1 μgr to 1.0 mgr per complete cycle of the integrator.—*Consolidated Electrodynamics Corp., Subs. of Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif.*

CIRCLE 366 ON READER-SERVICE CARD

FOR MORE PRODUCT DATA

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PRODUCT INDEX

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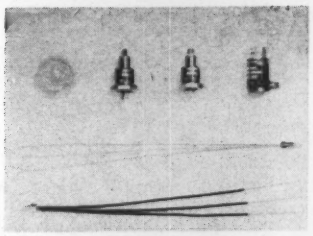
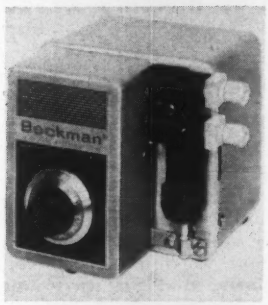
MINI TEMPERATURE SENSORS



New hermetically-sealed screw-in Temperature Sensors have tungsten- or platinum-wound element contained in silver or alloy housing with 2-56 to ¼"-20 threads, ⅜" long. Subminiature version is knurled with integral leads imbedded in glass. Guaranteed accuracy is 0.1% of full range from -452° to 1750° F.—*Temtro, Inc., 3016-C S. Halladay, Santa Ana, Calif.*

CIRCLE 367 ON READER-SERVICE CARD

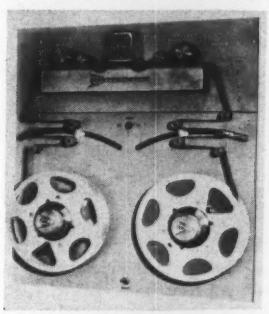
SOLUTION METER PUMP



New Solution Metering Pump is set by calibrated knob to thousandths of ml/min with accuracy of ±2% of full range. Repeatability is better than ±0.5% of rated capacity. Internal components are of highly inert materials for corrosive fluids. Available in 4 ranges 0-2 to 0-20 ml/min.—*Beckman Scientific and Process Instruments Div., Fullerton, Calif.*

CIRCLE 368 ON READER-SERVICE CARD

PERFORATED TAPE HANDLER



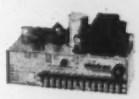
New Dykor Model 4577 high-speed bi-directional Perforated-tape Reader accepts 5-to-8-level tapes interchangeably, reads at speeds to 500 characters/sec, and rewinds at 1,000 characters/sec. 8" reels hold 500 ft of 4.5-mil tape or 1,000 ft of 3-mil tape.—*Digitronics Corp., Albertson Ave., Albertson, L. I., N. Y.*

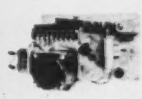
CIRCLE 369 ON READER-SERVICE CARD

± 3 micron sensitivity in this typical differential transformer application. The ATCOTRAN® differential transformer measuring probe continuously senses amount of stock removed from work piece during this grinding operation, stops feed above established grinding dimensions, and simultaneously starts timed dress-up. Automatic cut-off at end of dress-up actuates withdrawal and stops spindle motor. Probe tip may be equipped with diamond point, roller, shoe or other work contact element suitable for position, thickness or tolerance measurement. Displacement measuring range is from 0 to 0.025 inches.

(A)

(B)


(C)

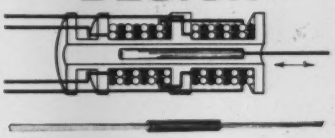

(D)

ATCOTRAN COMPONENTS

(A) Pressure Pick-up measures and controls flow of gas or liquid.
(B) Edge Guide senses edge position of continuous strips.
(C) Amplifier operates from input of any Atcotran sensing device.
(D) Servo Mechanism to position remote indicators with precise accuracy.

SYSTEM-PROVED STANDARD ATC DIFFERENTIAL TRANSFORMERS

INCREASE SENSITIVITY, SIMPLIFY CIRCUIT DESIGN



WHAT IS A DIFFERENTIAL TRANSFORMER? An electromechanical device which continuously translates displacement or position change into linear AC voltage.

WHAT ARE ITS ADVANTAGES? It is frictionless, has infinite resolution, high signal to noise ratio, low null voltage, unaffected by wide temperature ranges or radiation exposure, linear to 1/10th of 1%, small in size and weight.

WHERE ARE ATC DIFFERENTIAL TRANSFORMER SYSTEMS IN USE? In numerous industrial and military applications where sensitivity, economy, and consistent performance are demanded in a control or indicating system.

HOW CAN I FIND OUT HOW DIFFERENTIAL TRANSFORMERS WILL HELP ME?

Send for ATC's free 32 page "Handbook of Linear Transducers," which gives theory, characteristics, curves, schematics and application data.

HOW CAN I EXPERIMENT WITH DIFFERENTIAL TRANSFORMERS?

ATC's Experimental Kit offers all essentials for experimentation and development: technical data, seven transformers (linear range ± 0.01 to ± 2.5 inches), flexure plate and mounting clamp, and demodulator.

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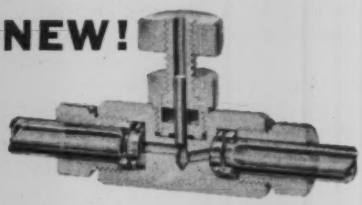
KING OF PRUSSIA, PENNSYLVANIA
A SUBSIDIARY OF SAFETY INDUSTRIES, INC.

CIRCLE 124 ON READER-SERVICE CARD

NEW!



...for High Vacuum Use... Teflon* Needle Valves With "O" Ring Seals**

Now . . . obtain flow control of highly corrosive fluids, under high vacuum! Manostat's new teflon needle valve both provides delicate flow control and utilizes rubber "O" rings, not in contact with the fluid, for high vacuum isolation from the surroundings without contamination!

In this newly designed valve, fluids touch only acid-and-alkali-resistant heavy wall pyrex brand glass connecting tubes, teflon valve body, and diamonite*** (sintered form of synthetic ruby) needle. All plastic parts not in contact with fluid are polypropylene — both corrosion resistant and able to withstand autoclaving temperatures. Result: no breakage, no contamination, dependable flow control!

PRICE LIST

Cat. No. NV1000—Teflon Needle Valve ready for use with directions but no glass parts. 6.95

Cat. No. NV1200—Glass connecting tube. 80mm. long..... .60

Cat. No. VB2000—Delivery tip..... .70

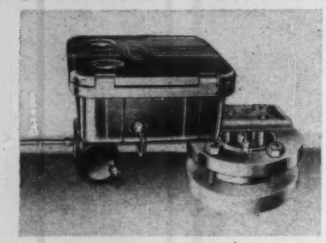
See Your Local Laboratory Supply Dealer

MANOSTAT Corporation
26 N. Moore St., New York 13, N.Y.

*DuPont trade name for polytetrafluorethylene **Patent applied for. ***Trade name for sintered corundum

CIRCLE 125 ON READER-SERVICE CARD

LIQUID LEVEL TRANSMITTER



New Type 115C liquid-level Transmitter for corrosive or viscous fluids is pre-calibrated for supply pressures between 18 and 40 psig. Accommodates Wizard controllers to convert output to standard pneumatic signal for use with recorder or control valve.—*Fisher Governor Co., Box 307, Marshalltown, Iowa.*

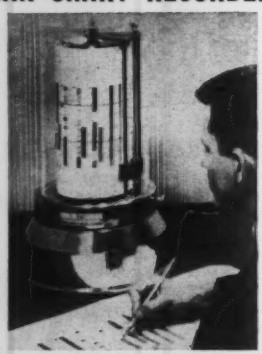
CIRCLE 370 ON READER-SERVICE CARD

AIR VELOCITY METER

New Flowtronic 55 Series Air Velocity Meter provides direct readings of air velocities 0 to 4000 fpm and air and surface temperatures 20° to 220°F. 8-transistor circuit provides rapid damped meter response and electrical output with d-c to 1-kc response. Powered by 115-vac or by rechargeable nickel-cadmium batteries. —*Flow Corp., 11 Carleton St., Cambridge, Mass.*

CIRCLE 371 ON READER-SERVICE CARD

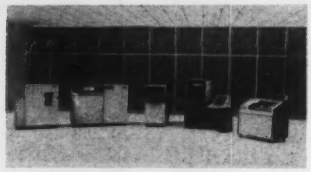
BAR CHART RECORDER



New Bar Chart Recorder monitors and records efficiency of utilization of up to 40 production or data processing machines and can be connected by telephone-type wires to the machines being monitored.—*Electronic Associates, Inc., Long Branch, N. J.*

CIRCLE 372 ON READER-SERVICE CARD

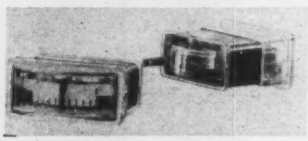
PUNCHED CARD COMPUTER



New B200-Family of small- and medium-scale Computing Systems includes the B250 (illustrated) which uses a hard-copy record processor in addition to punched-card handling equipment. Features are buffering temporary storage devices compensating for differences in speed against mechanical units, electron impulse triggering of magnetic band to move card into "read" position, etc.—*Burroughs Corp., Equipment & Systems Div., 6071 Second Ave., Detroit 32, Mich.*

CIRCLE 373 ON READER-SERVICE CARD

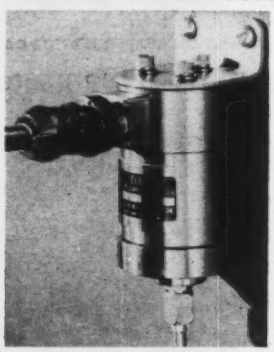
EDGE READING METER



New Edge-reading Meter series includes Model 12 (illustrated), miniature null-type zero-center-tuning Indicator with simple floating-coil-type movement which provides reliability, ruggedness, and precision accuracy. Model 13 reads (both ac and dc) various ranges from 1 ma to 100 amp with accuracies of 3 to 5%. Voltmeter ranges vary from 50 mv to 300 v.—*Electro-Mechanical Instrument Co., 8th & Chestnut Sts., Parkasie, Pa.*

CIRCLE 374 ON READER-SERVICE CARD

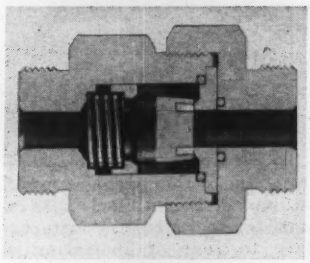
PRESSURE TRANSDUCER



New Model 176 Teledyne Pressure Transducer features high frequency response (due to extremely small s-s fluid-pressure cavity), pressure ranges from 0-300 to 0-10,000 psig. Suited for peroxides, liquid oxygen, alkalies, even fuming nitric acid. Measuring element is sensitive proving ring with 4 precision strain gages bonded to it.—*Taber Instrument Corp., 107 Goundry St., North Tonawanda, N. Y.*

CIRCLE 375 ON READER-SERVICE CARD

HI-PRESS CHECK VALVES



New line of Check Valves combining resilient nylon with pressure of spring closure, assures positive and leakproof shut-off at pressures to 6000 psi and temperatures —20° to 275°F. Sizes, ¼" to 2". Two types, in-line or globe.—*Combination Pump Valve Co.*, 848 *Preston St., Phila.* 4, *Pa.*

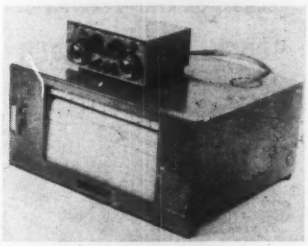
CIRCLE 376 ON READER-SERVICE CARD

TIMER

New Atcotrol 305B Automatic Reset Dial Timer is either aluminum-bezel flush-mounted or plugged in for quick range change. Synchronous-motor-driven unit for control of a-c or d-c loads within variable timed sequences or intervals features 14-point terminal block for easy handling of up to 7 individual load circuits, removable dial, solderless component connections, 16 dial ranges.—*Automatic Timing & Controls, Inc., King of Prussia, Pa.*

CIRCLE 377 ON READER-SERVICE CARD

RECORDER PLUG-INS



New Universal Recorder can operate as a standard fixed-span recorder or can function with one or more external plug-in modules. Family of 24 modules contains circuitry for recorder to function as strain-gage-, adjustable-span-and-zero-, resistance-bulb-, flow-, temperature-, pressure-, or potentiometer-following recorder. Modules feature calibrated controls. Instrument can be panel mounted or used on table-top for laboratory.—*Westronics, Inc.*, 3605 *McCart, Fort Worth* 10, *Tex.*

CIRCLE 378 ON READER-SERVICE CARD

MAGNETIC DIGITAL SYSTEMS

ORBITAL RELIABILITY at DOWN-TO-EARTH PRICES

DI-AN magnetic logic techniques solve digital problems in new and better ways every day. The satellite-borne digital velocity meter counter shown above, for example, was the smallest, lightest, lowest-power-drain solution to the problem last year, when we developed it. Today using PICO-BIT® CTL's, we can build it in one-third the space and weight.

Over 100 tough digital system problems each year yield to the power and elegance of our unique magnetic-logic approach. Counting, timing, programming, sequencing, and arithmetic requirements, from the simplest decade divider to a complete high-speed incremental digital computer, are drastically simplified, reduced in size, weight, power-drain, and cost — and are given space-vehicle reliability.

Write for our brochure 61-90 — all about DI-AN and its digital engineering capabilities. If you have a current system problem, call us today, and talk directly to one of our problem solvers.

®Pico-bit is a registered DI-AN trademark for its micro-micro-miniature logic elements.

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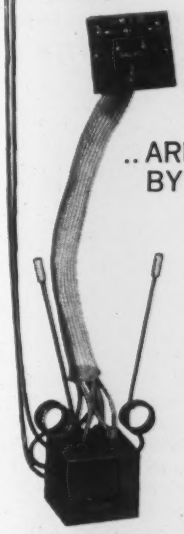
CIRCLE 126 ON READER-SERVICE CARD

THERMAL CONDUCTIVITY DETECTORS AVAILABLE FROM ALL 16 CHROMATOGRAPH MAKERS

See Chemical & Engineering News, July 3, 1961 Issue

GOW-MAC MODEL 9285 (PRETZEL SPECIAL)



Gow-Mac Hot Wire Filaments or Cells

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For YOUR best GC detector performance around the clock insist on GOW-MAC for quality, experience and fast delivery. New Gow-Mac Bulletins on Chromatograph Components:

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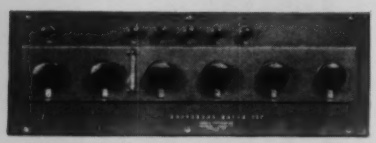
FOR STANDARDIZING LABORATORIES

2L&N CERTIFICATION INSTRUMENTS

4394 FOUR-DIAL KELVIN-WHEATSTONE RATIO SET

For certification of N.B.S. (Rosa) and Reichsanstalt-type Standards. This precise ratio device calibrates high accuracy d-c resistance standards having values from 0.001 ohm to 100,000 ohms, in decimal multiples or submultiples of 1 ohm. It can be used for either two-terminal Wheatstone-bridge or four-terminal Kelvin-bridge measurements. The 4394 covers a range of 99.5000% to 100.6110% in steps of 0.0001% (1 ppm).



4393 SIX-DIAL UNIVERSAL RATIO SET

For calibration of precise bridges and potentiometers. Primarily intended for certifying instruments such as L&N's Type K-3 Potentiometer and the 4232-B Wheatstone Bridge, this 4393 Ratio Set may also be used for the calibration of resistance standards and odd-value resistors. It has a nominal resistance of 2111.11 ohms with a limit of error of 0.002% for dial changes of 100 ohms or more, and 0.002 ohm for dial changes of less than 100 ohms.

These "top-of-the-line" instruments can help you achieve the ultimate in accuracy in your laboratory. For Data Sheets E-53(13) on the Kelvin-Wheatstone Ratio Set, and E-53(12) on the Universal Ratio Set, write today to your nearest L&N Office or to Leeds & Northrup Company, 4955 Stenton Ave., Phila. 44, Pa.

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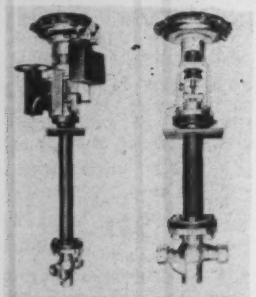
CIRCLE 128 ON READER-SERVICE CARD

PRESSURE CELL

New semiconductor strain-gage mini Pressure Cell permits precise static measurement in addition to very fast rise time and flat frequency response over wide range of dynamic measurements. Capacities from 5 to 500 psig provide outputs in excess of 100 mv with natural frequency in excess of 50 Kc. Bulletin.—*Kulite-Bytrex Corp., 50 Hunt St., Newton 58, Mass.*

CIRCLE 379 ON READER-SERVICE CARD

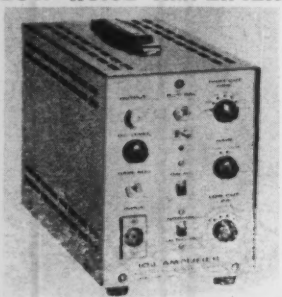
CRYOGENIC CONTROL VALVES



New globe-type Cryogenic Control Valves feature zero leakage through cool down, on-stream runs and defrost periods, Cage-Trim design without seat ring threads, complete disassembly of valve from top end. Available in ½" to 4" bronze or aluminum, and ½" to 2" stainless-steel bodies.—*Leslie Co., 120 Delafield Ave., Lyndhurst, N. J.*

CIRCLE 380 ON READER-SERVICE CARD

LOW NOISE AMPLIFIER



New Model 103 A-C Preamplifier has noise level of less than 0.8 μv rms between 10 cps and 10 kc, lowers microvolt measurement threshold over bandwidth of 0.1 cps to 100 kc. Applications include measurement of piezoelectrical crystal outputs, a-c Hall-effect studies, a-c-bridge null indicators, and investigations of 1/f noise in semiconductors.—*Keithely Instruments, 12415 Euclid Ave., Cleveland 6, Ohio.*

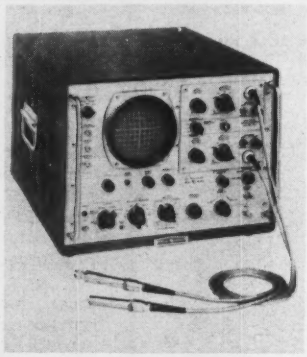
CIRCLE 381 ON READER-SERVICE CARD

VACUUM GAGES

New line of Compact Vacuum Gages features self-contained miniature transistorized circuitry attached directly to rear of indicating meter. Complete gage mounts in panel or on polished brass stand. Operates on thermopile principle. 3 ranges, 0.2 μ Hg through 20 mm Hg.—*Hastings-Raydist, Inc., Hampton, Va.*

CIRCLE 382 ON READER-SERVICE CARD

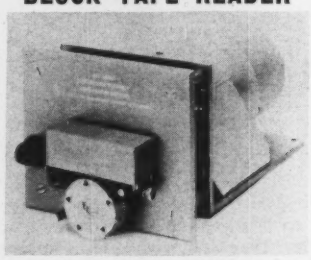
SAMPLING OSCILLOSCOPE



New Model 185B Sampling Oscilloscope features conventional controls, direct reading, bright-trace observation, and a standard 5" mono-accelerator CRT. When equipped with a Model 187B Plug-In Dual Trace Amplifier, it has pass band from dc to 1000 Mc, can be synchronized up to 1000 Mc, and permits full-screen presentation of signals from 0.3 nanosecond to 100 μsec.—*Hewlett Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.*

CIRCLE 383 ON READER-SERVICE CARD

BLOCK TAPE READER



New 400-Series Block Tape Reader features modular design allowing 3 reader sub-assemblies to be combined with single 400-Series Control Unit to make up a tape reader for 80-, 96-, or 120-bit tape frames. All models read standard 8-level perforated tape, with no special punch required.—*Automation Div., Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.*

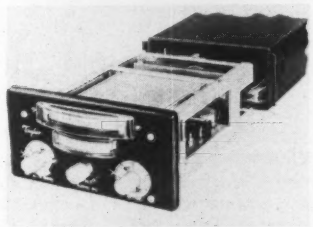
CIRCLE 384 ON READER-SERVICE CARD

CROSSBAR SCANNER

New ST-2-Series multiplexing Crossbar Scanners accommodate up to 100 one-wire, 60 two-wire, or 40 three-wire channels. Specifications include digital, edge-lighted readout; 20-million operations/crosspoint; 100 μsec bounce on make, none on break; current capacity of 1000 ma at 50 vdc; signal frequency range from dc to 10 Mc.—*James Cunningham, Son & Co., 33 Litchfield St., Rochester, N. Y.*

CIRCLE 385 ON READER-SERVICE CARD

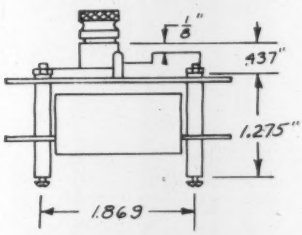
CONTROL STATIONS



New 701K-Series of Electronic Indicating Control Stations for 24-v and 1-v systems features chassis partially removable from its case while still on control, large 3" process meter and 2" output meter, with calibration based on 1-5 ma dc. Multi-position switch permits automatic and/or manual control modes. Bulletin 98393. —*Taylor Instrument Companies, 95 Ames St., Rochester 1, N. Y.*

CIRCLE 386 ON READER-SERVICE CARD

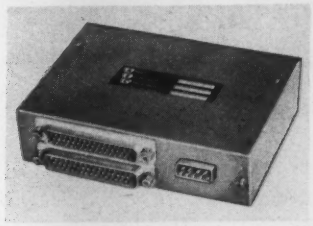
CLOCK MOVEMENT



New Model 585.32 spring-wound, counter-clockwise-rotation Eight-day Clock Movement is geared for either one rotation every 24 hrs or one rotation every 7 days. Silicone lubricated, it operates at temperatures from —40° to 220°F. Torque capacities (in in-oz) at stall: 24-hr starting torque —74; 24-hr end torque—39; 7-day starting torque—362; 7-day end torque—155. Recommended maximum operating torque is 10 in-oz for 24-hr model and 40 in-oz for 7-day model.—*Pacific Transducer Corp., 11836 W. Pico Blvd., Los Angeles 64, Calif.*

CIRCLE 387 ON READER-SERVICE CARD

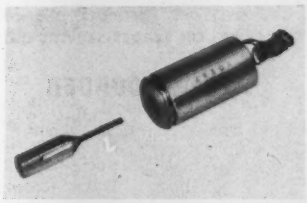
ELECTRONIC MULTICODER



New Electronic Multicoder allows transducer source resistances to 5 megohms or is used with no disturbance of sampled circuit. Input impedance at 1000 cps is 150 kilohm. Also available is 9 x 200 system for direct sampling of crystal or other high impedance transducers with data frequency response to 50 cps.—*Applied Electronics Corp. of N. J., 22 Center St., Box 43, Metuchen, N. J.*

CIRCLE 388 ON READER-SERVICE CARD

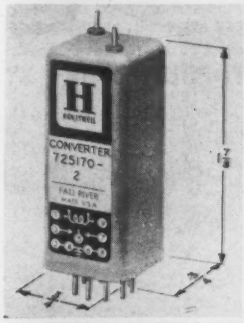
SOLENOID



New push-type Synchronoid Precision Solenoid packaged in 1½" dia x 2⅞" synchro case mounts in 1.375" dia pilot hole, has spring force of 3 lb at 0.4" stroke and 7.5 lb at 0 stroke. Anti-rotational plunger is restrained to ±5° max rotation. Pull-in coil takes 2.7 amp at 26 v/75°F, holding coil takes 0.125 amp at 26 v/75°F. —*A R & D A, 135 Main St., Belleville 9, N. J.*

CIRCLE 389 ON READER-SERVICE CARD

MINI CONVERTER



New Model 725170 Miniature Converter for servo amplifier systems, computers, telemetry, and multiplexing equipment is less than 2" high, and has extremely low noise level due to special magnetic shielding and isolation of driving coil from contact circuit. Plugs into standard nine-pin miniature socket. —*Minneapolis-Honeywell Regulator Co., Fall River, Mass.*

CIRCLE 390 ON READER-SERVICE CARD

Lepel

High Frequency

INDUCTION HEATING UNITS

Lepel induction heating equipment is the most practical and efficient source of heat developed for numerous industrial applications

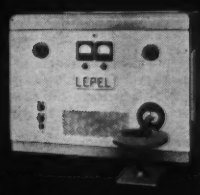
LEPEL ELECTRONIC TUBE GENERATORS

STANDARD UNITS
Frequencies: 180 Kc to 600 Kc
Sizes: 1 Kw to 100 Kw output

MEGACYCLE UNITS
Frequencies: 3 Mc to 50 Mc
Sizes: 2½ Kw to 20 Kw output

DUAL FREQUENCY UNITS
Sizes: 5 Kw, 10 Kw & 20 Kw output

LEPEL SPARK GAP CONVERTERS
Frequencies: 400 Kc to 900 Kc
Sizes: 2 Kw to 30 Kw input



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NOW YOU CAN BUY

OFF THE SHELF! FOR IMMEDIATE SHIPMENT*

transmitters (1HG, 1HG400, 5HG, 5HG400)
. . . angle transmission units for torque transmission and servo control systems.

receivers (1F, 1F400, 5F, 5F400)
. . . used as receivers in torque transmission systems. Have shaft damping to prevent oscillation and overcome any tendency to spin.

control transformers (1HCT)
. . . produce an a-c voltage at the rotor terminals that depends on rotor shaft position and the voltages applied to windings.

differential transmitters (1HDG, 5HDG)
. . . "add in" other shaft positions when connected between transmitter and receiver or control transformer.

Use Telesyn synchros for extremely accurate drives and indicators of position, pressure, flow or other synchro-transmitted information.

A pioneer in the field of synchronous transmissions, Ford Instrument Company produces synchros of proven precision.

- Available to meet MIL specs.
- In sizes to meet a multiple of requirements.
- For torque transmission and voltage indication.

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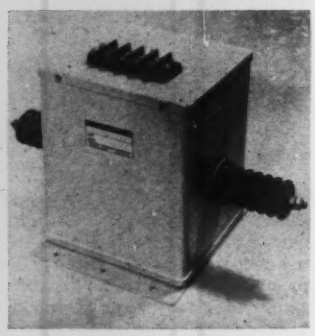
1.3

FORD INSTRUMENT COMPANY

Division of The Sperry Rand Corporation
31-10 Thomson Ave., Long Island City 1, N. Y.

CIRCLE 130 ON READER-SERVICE CARD

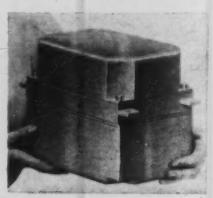
CURRENT TRANSDUCTORS



New line of 8 standard shunt-type current Transductors controls and monitors fields and armatures of motors to 100 amp. Shunt type is complementary to installed 50-mv or 100-mv standard shunts for measurement of currents to 20,000 amp. Bus-tap type is connected directly to bus bars carrying from 20,000 to 200,000 amp dc.—*Norbatrol Electronics Corp., 356 Collins Ave., Pittsburgh 6, Pa.*

CIRCLE 391 ON READER-SERVICE CARD

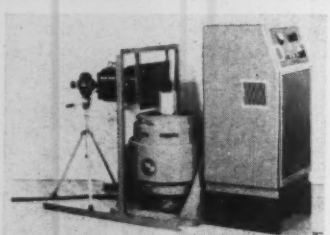
DATA RECORDER



New 13-pound airborne magnetic-tape 2101 Data Recording System consists of precision tape transport and electronic module assembly. Choice of 14 tracks of wideband F-M recording or seven tracks of wideband F-M and 7 tracks of direct analog recording can be made by changing plug-in modules. System produces accurate data during missile launch and flight for use after recovery or in-flight reproduction.—*Westrex Recording Equipment Div., 335 N. Maple Dr., Beverly Hills, Calif.*

CIRCLE 392 ON READER-SERVICE CARD

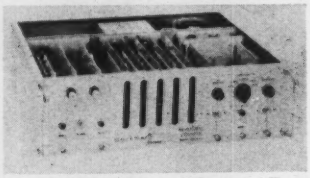
MULTI-PULSE X-RAY SYSTEM



New multiple-pulse X-ray System charts performance of totally enclosed moving parts. Developed by Zenith Radio Research, it has capacity of 30 pulses/sec permitting specimen studies over wide frequency and velocity ranges, which are recorded on film.—*MB Electronics, Div. of Textron Electronics, Inc., 781 Whalley Ave., New Haven 8, Conn.*

CIRCLE 393 ON READER-SERVICE CARD

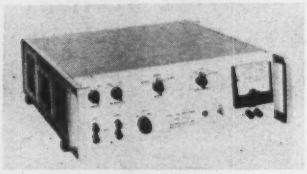
REVERSING COUNTERS



New Model 3300 solid-state Reversing Counters count "up" or "down" at rates to 200,000 cts/sec. Ideal for bi-directional position indication, frequency difference measurements, and algebraic summation of two discrete events. Many optional features available. Bulletins.—*Beckman Instruments, Inc., Berkeley Div., 2200 Wright Ave., Richmond, Calif.*

CIRCLE 394 ON READER-SERVICE CARD

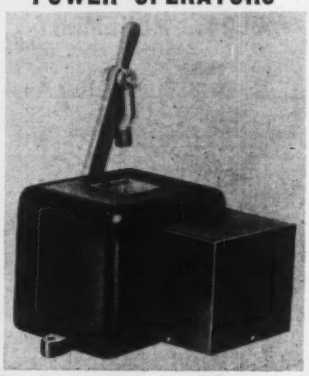
FM STEREO MODULATOR



New Type 219-A FM Stereo Modulator provides multiplex output signal in accordance with FCC Docket 13506. Modulates Type 202-E Signal Generator (or other FM Signal Generators with adequate modulation characteristics) when fed with Left (L) and Right (R) audio-stereo-channel inputs and/or subsidiary-communications FM sub-carriers (SCA). Provides either L+R, L-R (AM), 19-kc pilot carrier outputs or complete composite multiplex signal.—*Boonton Radio Corp., Boonton, N. J.*

CIRCLE 395 ON READER-SERVICE CARD

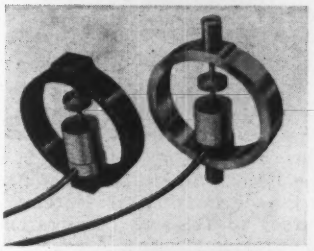
POWER OPERATORS



New line of Powertork® Power Operators for electrical control drives consists of 3 models with output torques of 30, 60 and 120 ft-lb at ½ rpm. Special 4-stage gear train and 1800-rpm reversible-split-capacitor-type drive motor are completely immersed in high-dielectric, radioactive-shielding oil suitable for 30° to 200°F. —*Reliance Instrument Div., Electro-Mech Corp., 500 Livingston St., Norwood, N. J.*

CIRCLE 396 ON READER-SERVICE CARD

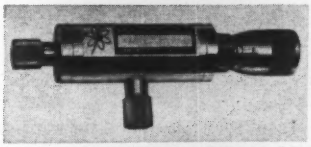
FORCE TRANSDUCERS



New Type PR-35 stainless-steel Load Cell employs calibration-quality proving ring coupled inductively to ultrasensitive differential transformer. Provides more than 500-mv output with 10 v/60 cps input, or more than 1 v with 10 v/400 cps input. Frictionless movement insures exceptional repeatability. Picks up static or dynamic forces. Load ranges are 25 to 4000 lb, tension or compression. —*United Aero Products Corp., Burlington, N. J.*

CIRCLE 397 ON READER-SERVICE CARD

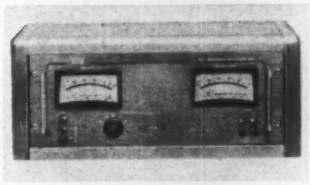
METERING VALVE



New Vari-Vac Model VV-50 Metering Valve adjusts pressure in vacuum vessels from 10^{-7} mm Hg to 1 atm, allows accurate adjustment of flow rates from approximately 0.01 to 5 std. cc/sec due to non-rotating linear bellows-sealed micro-groove stem. Available in nickel plated brass or stainless steel, with quick-connect or sweat fittings.—*Vactronic Lab., Equipment, Inc., East Northport, N. Y.*

CIRCLE 398 ON READER-SERVICE CARD

STATISTICAL COMPUTER

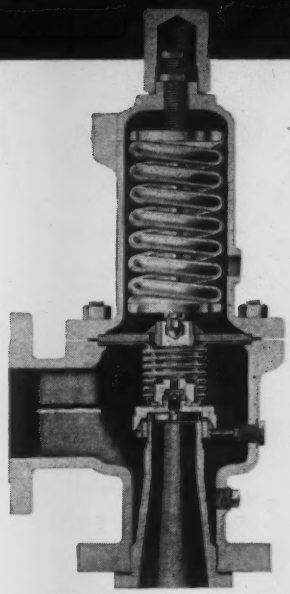


New on-line Statistical Computer utilizes histogram data, continuously computes and indicates mean value and standard deviation. Made in three different basic models: One model accepts input information from continuous-output devices, such as monitors, programmers, meters, etc.; another model accepts input information from relay closures, switches, and similar on-off devices; a third model has keyboard for entering information manually. All models respond immediately to any change in input data. Bulletin 91436B.—*Boonshaft and Fuchs Inc., Hatboro Industrial Park, Hatboro, Pa.*

CIRCLE 399 ON READER-SERVICE CARD

value...

the reason FARRIS OUTSELLS all others



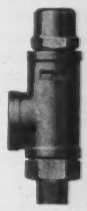
Series 2600 . . Balan-Seal bellows. 150 to 6000 psig. Also without bellows.

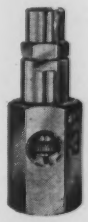
Farris Process Safety-Relief valves have unique design features which provide product serviceability and dependability unmatched by *any* competitive valve. True value is "built into" Farris valves.

- **2½ to 1 ratio—guide length to guide diameter—prevents galling and hanging up.**
- **High thermal expansion of sleeve guide and low thermal expansion of hardened stem retainer stops binding at high temperatures.**
- **Hardened stainless steel optically lapped disc . . . self aligning for maximum tightness.**
- **Elimination of effects of back pressure by "BALAN-SEAL" bellows permits use of smaller discharge piping . . . Saves up to 15 times the cost of the valves . . . isolates internal working parts from lading fluid.**
- **Industry's most complete line. Available in cast iron, steel and special materials. Sizes ½" to 8". Pressures to 10,000 psig. Temperatures to 900°F. Enclosed or exposed springs. Plain, open lever or packed lever construction.**

All Farris Nozzle Valves Conform To ASME Power Boiler Code, Section 1, and The ASME Unfired Pressure Vessel Code, Section 8.

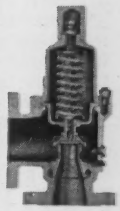
Series 2740 & 2741 . . . simple, rugged cast steel design. Pressures to 5000 psig @ 750°F.





Series 2745 . . . Durable, compact, high pressure nozzle valve. Internal parts 316 stainless steel. Pressures to 10,000 psig.

Series 2950 . . . Cast iron valve similar to Series 2600. Max. pressure 250 psig. @ 450°F, 400 psig. @ 150°F.



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CIRCLE 131 ON READER-SERVICE CARD

PHOTOTRON

FIRST IN NEW LINE OF ANALOG TO DIGITAL CONVERSION PRODUCTS FROM HYDRO-AIRE

This highly versatile basic transducer offers incremental conversion of shaft angle to digital measurement. Available in seven models, its maximum permissible speeds range from 15,000 rpm at 128 counts per revolution to 1,250 rpm at 2,048 counts, with sample rates ranging to 45,000 counts per second.

Applications for the Hydro-Aire Phototron include analog to digital shaft converters, precision analog servo with digital readout, data reduction equipment, tachometers, and precision measurement and control.

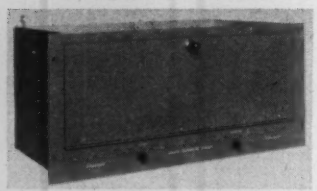
Detailed specifications are available on request. Related products soon to be available from Hydro-Aire, a member of the Crane Co. Systems and Controls Group, will include associated power supplies and binary and digital counters.

HYDRO-AIRE
DIVISION OF
CRANE

3000 WINONA AVE., BURBANK, CALIF.

CIRCLE 132 ON READER-SERVICE CARD

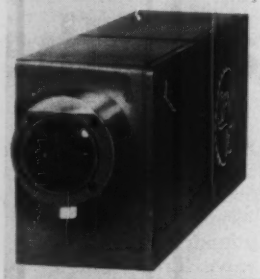
MONITORING SYSTEM



New all solid-state modular Datrax Binary Reporting System scans up to 256 points for off-normal conditions, encodes and transmits binary signals to an identically packaged receiver and decoder for actuation of alarm, display and control circuits. Scan rate is 5000 pps; output is 12 v at 1 amp.—*W. W. Henry Co., Datrax Div., 4443 E. Slauson Ave., Maywood, Calif.*

CIRCLE 400 ON READER-SERVICE CARD

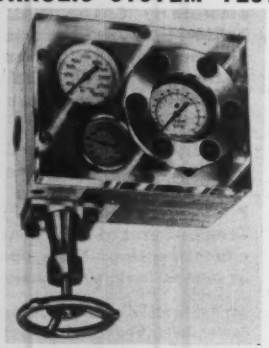
INFRARED PYROMETER



New Servotherm® compact Infrared Industrial Pyrometer covers wave length spectrum from 1-12 μ, measures and controls temperature of any size object, stationary or moving. Features include transistorized circuits, wide temperature range, high accuracy.—*Servo Corp. of Amer., Inc., 111 New South Rd., Hicksville, L. I., N. Y.*

CIRCLE 401 ON READER-SERVICE CARD

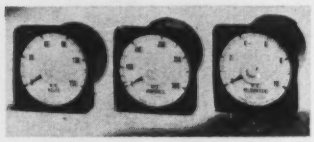
HYDRAULIC SYSTEM TESTER



New Hydra-Sleuth incorporates flow, pressure, temperature gages, and load-valve; measures 5" x 6" x 8". Flow gage comes in two scale ranges (0 to 10 and 6 to 30 gpm); pressure gage indicates up to 3000 psi; and temperature gage reads 20 to 240°F.—*Schroeder Brothers Corp., Nichol Ave., Box 72, McKees Rocks, Pa.*

CIRCLE 402 ON READER-SERVICE CARD

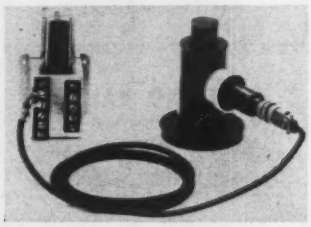
ELECTRICAL INDICATORS



New Type JA a-c, Class 9117; and Type JD d-c, Class 9116, line of 4½" long-scale instruments features 1% accuracy of full-scale, easily removable swinging element. A-c meters include ammeters; voltmeters; wattmeters and varmeters (both single phase; polyphase, 3-phase/3 wire; and 3-phase/4 wire); and frequency meters. D-c ammeters and voltmeters available.—*Federal Pacific Electric Co., 50 Avenue L, Newark 1, N. J.*

CIRCLE 403 ON READER-SERVICE CARD

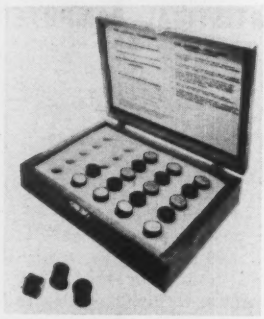
LOAD CELL



New self-contained solid-state Force Control Cell is actuated by 0.001"-to-0.005" deflections acting on special sensor unit (not a piezo crystal). Capacities range from 5000-1000 to 75,000-500,000 lb. Accuracy is within 3% of maximum rating, repeatability within 1%, response is instantaneous; life rating is 25 million cycles.—*Force Controls Co., 4245 W. 8 Mile Rd., Ferndale, Mich.*

CIRCLE 404 ON READER-SERVICE CARD

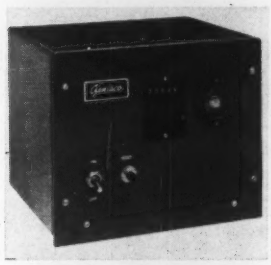
TRANSFORMER CHEST



New pulse-transformer Test-Chest contains 25 miniature transformers offering more than 500 performance-characteristic variations. Fit seven-pin sockets on breadboards. Units included have turns ratios of 1:1:1, 2:1:1, 4:1:2, and 4:1:4. Windings can be combined to give up to 8:1 turns ratios. Inductive values range is 50 to 140 mh.—*Pulse Engineering, Inc., 560 Robert Ave., Santa Clara, Calif.*

CIRCLE 405 ON READER-SERVICE CARD

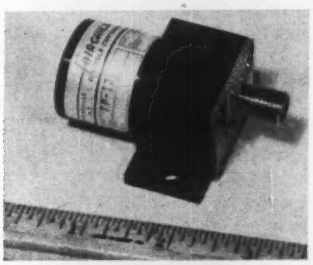
SOLID STATE COUNTER



New transistorized Model HA 4000A Counter provides speeds to 15,000 cts/min. Consists of one decade of electronic counting followed by five decades of electromechanical registering on neon glow transfer tube.—*Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.*

CIRCLE 406 ON READER-SERVICE CARD

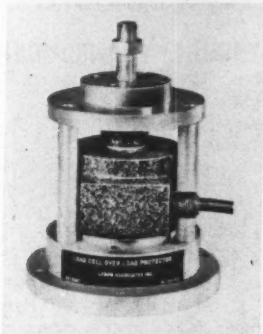
PRESSURE TRANSDUCER



New Model TP-125 Potentiometric Pressure Transducer has range of 0-5 to 0-500 psi, absolute, gage, or differential. Precision wirewound potentiometers feature precious-metal contacts and resistance wires, excellent resolution, and functional accuracy.—*Fairchild Controls Corp., Subs., of Fairchild Camera and Instrument Corp., 225 Park Ave., Hicksville, L. I. N. Y.*

CIRCLE 407 ON READER-SERVICE CARD

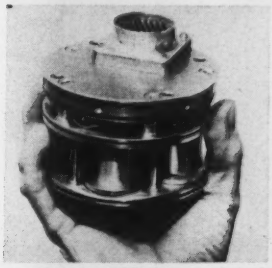
OVERLOAD PROTECTOR



New Overload Protector for use in dynamometer torque measurements, etc. utilizes mechanical stops capable of an overload factor of 30:1 with a patented non-linear spring network that protects in both tension and compression. Standard models cover 50-to-10,000-lb. load cells.—*Lebow Assocs., Oak Park, Mich.*

CIRCLE 408 ON READER-SERVICE CARD

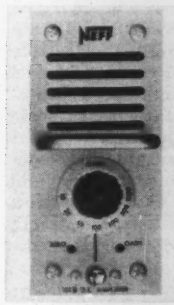
MINI TAPE RECORDER



New Model MR-21 multi-channel a-c or d-c miniature Magnetic Tape Recorder records up to 14 channels of data simultaneously on 1" magnetic tape up to 69 feet long. Withstands vibration through 50-2000 cps to 20 G's axially and 50 through 2000 G's at 10 G's transverse. Records through 1000 G's, 3-msec shock with power of 22 watts.—*Borg-Warner Controls, Box 1679, Santa Ana, Calif.*

CIRCLE 409 ON READER-SERVICE CARD

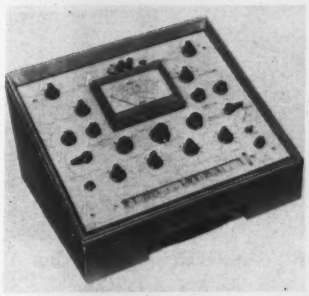
DIFF DC AMPLIFIER



New Type 101B solid-state Differential D-C Amplifier, amplifies low-level signals in the 0-100-cps frequency range. Circuitry features input impedance greater than 1 megohm, output impedance of less than ½ ohm, high slewing rate of 5000 v/sec, ideal filter isolation accomplished by low-pass plug-in filter internal to amplifier.—*Neff Instrument Corp., 1088 E. Hamilton Rd., Darte, Calif.*

CIRCLE 410 ON READER-SERVICE CARD

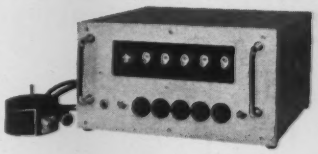
POWER TRANSISTOR TESTER



New Model 1885 transistorized Power Transistor Tester tests transistors to 50 amp of IC, power diodes to 5 amp of forward current, and Zener diodes to leakage current of 150 ma.-I_{cbo}, I_{ceo}, I_{ebo}, DC Beta, input impedance, Zin, output impedance H_{oe}, GM in μmhos and mho. Determines also Alpha and collector voltages and V_{cc} (SAT).—*Hickok Electrical Instrument Co., DuPont Ave., Cleveland 8, Ohio.*

CIRCLE 411 ON READER-SERVICE CARD

BI-DIRECTIONAL COUNTER



NEWEST IN NEW LINE OF ANALOG TO DIGITAL CONVERSION PRODUCTS FROM HYDRO-AIRE

This highly versatile, 45,000-count-per-second readout device indicates true position while going through zero in either direction. No need for external reset to establish reference, thus reducing the cost and complexity of related devices while simplifying system design and maximizing reliability. Modular construction of this compact, fully transistorized counter includes self-contained power supply and output connector.

When used with Hydro-Aire's Phototron transducer, this new counter converts inputs to Nixie tube visual readout and to digital type electrical readout for information storage, automatic machine control and process control systems — wherever precision numerical readout is required.

Detailed specifications on this and related products now available from Hydro-Aire are yours on request.

HYDRO-AIRE
DIVISION OF
CRANE

3000 WINONA AVE., BURBANK, CALIF.
Solid-state devices include time delay devices, voltage regulators, power supplies, inverters.

CIRCLE 133 ON READER-SERVICE CARD

STOP Voltage DRIFT AND ELIMINATE FREQUENT RESTANDARDIZATION OF PRECISION POTENTIOMETERS!

USE THE *evenvolt* D.C. CURRENT SUPPLY

Replace Drifting Wet or Dry Batteries!

End Wet Cell Acid Hazard!

Use with L & N K2 or K3, M-H Rubicon Type B or Similar Laboratory Potentiometers

- **Input**—100-135 V AC 50-60 C
- **Output**—Volts: 1.4, 2.0, 2.5, 3.0, 4.0 or 6.0 V DC Nominal (Others Available)
  Current: 1.0, 8.0, 10.0, 11.0, 22.0, 24.44 or 25.00 Ma. (Others Available)
  Line Voltage Regulation: Maximum .01%
  Ripple: Max. 0.001%
  Isolation: Less than 1 mmfd. to line
  Temperature Coefficient: Less than 0.0005%/°C
- Case—18 Ga. steel, bonderized, enameled

OTHER EVENVOLT MODELS

Model 201 Reference Unit
Eliminates Batteries, Standardizing Circuit and Components
For Self-Balancing Potentiometers L & N, M-H, Bristol, Wheelco, West, Weston and others.
Battery Size For Mounting In All Instruments. Complete installation instructions included with each unit.

Model 300 DC Potential Source
For Calibrating, Self-Balancing and Manual-Balance Potentiometers and other instruments of high input impedance. For bucking potentials in electro-chemical measurements. Supplies isolated, adjustable, accurate, stable, DC Potential at 0-1000, 0-100, 0-50 MV.

Model 500 DC Regulated Power Supply
For Use As Power Supply For Strain Gages, Resistance Bridges; as voltage standards, filament source, etc. Supplies isolated, regulated, stable DC voltage 0-10 at currents up to 50 Ma.

Model 600 DC Voltage Reference Unit
For Use As Bucking Potential, Reference Voltage, etc. Supplies an isolated, accurate, stable voltage of 1.000, 1.019, 6.2, 8.4, 9.0, 9.3, 11.7 at currents of 0.5, 1.0, 10.0 Ma.

Representatives In All Principal Cities. Write for complete specifications and engineering data.

INSTRULAB, INC.

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Dayton 4 • Ohio
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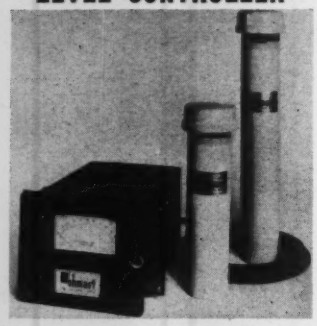
CIRCLE 134 ON READER-SERVICE CARD

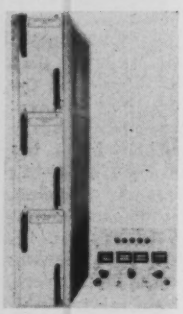
LEVEL CONTROLLER



New Liquid-level controller uses Geiger-Mueller principle of radiation detection, has sensing heads housed in thick steel tubes to meet explosion proofing. Suitable for high- or low-viscosity materials, remote (500 ft) recording, almost any size or type of vessel, also as radiation monitor for industrial areas.—*Ohmart Corp.*, 4241 *Allendorf Dr., Cincinnati 9, Ohio.*

CIRCLE 412 ON READER-SERVICE CARD

DIGITAL MULTIPLE METER



New Model 5126A solid-state Digital Multiple Meter offers high-speed automatic full scale ranging, output suitable for computer entry and visual readout. Integrated unit incorporates d-c voltage digitizer, a-c-to-d-c voltage converter, resistance-to-dc converter, reactance-to-dc converter, internal standards, and remote control panel.—*Ortonix, Inc., P. O. Drawer 8217A, Orlando, Fla.*

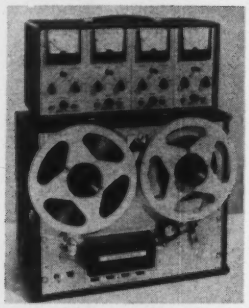
CIRCLE 413 ON READER-SERVICE CARD

FILM TILTING UNIT

New Automatic Film Tilting Unit was designed and produced by Photomechanisms (in collaboration with Eastman Kodak Co. and Xerox Inc. for Melpar Inc.) as part of complex electronic ground data handling system for Convair B-58 Weapons System. Film passes through unit at rates from 15 to 25 ft/min with aircraft data being printed on film at 170 characters/sec. Accommodates film widths of 9-12", 70 mm, and 35 mm.—*Photomechanisms, Inc.*, 6 *W.* 18 *St., Huntington Station, L. I., N. Y.*

CIRCLE 414 ON READER-SERVICE CARD

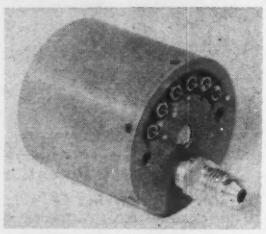
DATA RECORDING SYSTEM



New portable transistorized 4-channel Model M204 Analog Recording-and-Reproduction Systems, designed around pulsed-FM principle, handles analog data from 0-800 cycles, features 10 1/2" tape reel capacity, selection of speed ratios, low noise, low crosstalk, wide dynamic range, and independent recording and reproduction channels.—*Mnemotron Corp.*, 47 *S. Main St., Pearl River, N. Y.*

CIRCLE 415 ON READER-SERVICE CARD

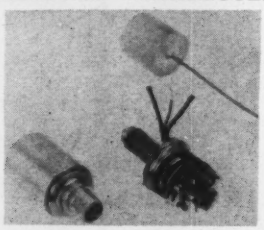
PRESSURE TRANSDUCER



New TP200 Pressure Transducer measures absolute, gage or differential pressures of corrosive and non-corrosive gaseous or liquid media, with static or dynamic inputs, in the ranges of 0-5 to 0-100 psi full-scale. Linear or nonlinear potentiometer outputs are standard.—*Fairchild Controls Corp., Subs. of Fairchild Camera and Instrument Corp.*, 225 *Park Ave., Hicksville L. I., N. Y.*

CIRCLE 416 ON READER-SERVICE CARD

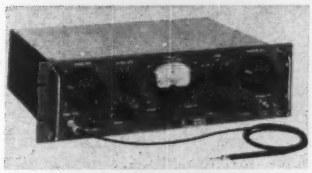
PRESSURE TRANSDUCER



New 1" Model TP-100 Pressure Transducer takes shock, acceleration, and vibration like no other pressure transducer its size. Output signal resolution is better than 0.25% in most ranges. Available in absolute-, gage- or differential-pressure versions in 0-5-to-0-500 psi range.—*Fairchild Controls Corp., Subs. of Fairchild Camera and Instrument Corp.*, 225 *Park Ave., Hicksville L. I., N. Y.*

CIRCLE 417 ON READER-SERVICE CARD

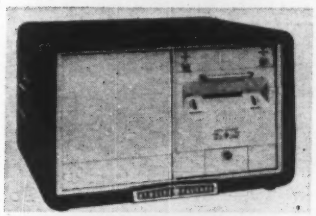
COMPLEX RATIO BRIDGE



New Model CRB-4 all-solid-state Complex Ratio Bridge measures both in-phase and quadrature voltage ratios of any 3- or 4-terminal network. Features self-contained, phase-sensitive null indicator. In-phase measurement accuracy is greater than 0.01% of range. Quadrature accuracy is greater than 0.1% of range.—*Gertsch Products, Inc., 3211 S. La Cienega Blvd., Los Angeles, Calif.*

CIRCLE 418 ON READER-SERVICE CARD

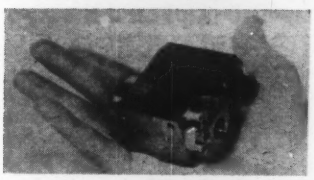
DIGITAL RECORDER



New Model 562A transistorized electromechanical Recorder can print up to five 11-digit lines/sec. Storage feature allows data transfer in 2 msec. Standard input is a 4-line BCD (1-2-2-4). Other four-line codes can be used by substituting plug-in cards. —*Hewlett Packard Co., 1501 Page Mill Rd., Palo Alto, Calif.*

CIRCLE 419 ON READER-SERVICE CARD

PRESSURE TRANSDUCER



New Model 990S100 Pressure Transducers operate in corrosive and non-corrosive liquid or gaseous media. Features include piezo-resistive sensing elements, exceptional accuracy, maximum reliability, infinite resolution, temperature compensation, and unexcelled repeatability. — *Fairchild Controls Corp., Subs. of Fairchild Camera and Instrument Corp., 225 Park Ave., Hicksville, L. I., N. Y.*

CIRCLE 420 ON READER-SERVICE CARD

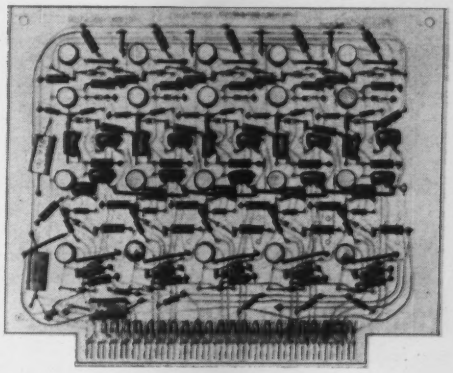
For More Information on Products Listed Please Circle the Corresponding Number on Reader-Service Card

DREXEL

CARD CIRCUITS

offer exceptional

ECONOMY
FLEXIBILITY
RELIABILITY



DREXEL CARD CIRCUITS, designed for medium to large size digital systems, supersede the usual high cost conventional logic card systems. Operating in the medium speed range, they achieve the inherent reliability of transistor switching circuits without the use of redundant elements or premium components. The Drexel capability for producing any logic with the fewest simple circuits as elements, results in economical card circuits which meet the most stringent government or commercial specifications. Card size and other parameters are selected to provide the most efficient overall system. Input and output circuits are available on same type of card as used for logic operations.

OPERATIONAL FEATURES

- NAND, NOR and Diode Logic available
- Twenty card types provide flexibility
- Decoupling of power supplies on each card
- "Worst-Case" design plus 50% derating
- Staked on hermaphrodite terminals
- Clamped outputs at 0 and minus 6 volts

DREXEL DYNAMICS CORPORATION

Horsham, Pennsylvania
WAverly 7-6200

CIRCLE 135 ON READER-SERVICE CARD

FIRST AND ONLY

RECORDING pH METER

Permanent pH Record • Simple to Operate • Adaptable • No Ink

A pH meter and strip chart recorder in one. Line operated. Continuously indicating. Can record continuously for 31 days at one inch per hour. With manual temperature compensator. Write for Bulletin No. 3R.

Price $245.00 complete, with Analytical protected pH probe unit

ANALYTICAL MEASUREMENTS, INC.

585 Main Street
Chatham, New Jersey

CIRCLE 136 ON READER-SERVICE CARD

TANK-O-METER

FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

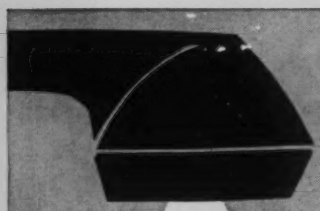
TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
Pressure and Vacuum
Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.

UEHLING INSTRUMENT CO. 470 GETTY AVE., PATERSON, N. J.

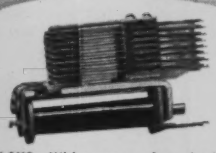
CIRCLE 137 ON READER-SERVICE CARD



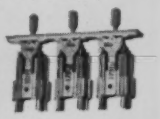
WHEN QUALITY IS A MUST

Stromberg-Carlson®

TELEPHONE-TYPE COMPONENTS



RELAYS: Wide range, for electro-mechanical switching. Send for Bulletin T-5000R2.



KEYS: Cam-type and push-button. Send for Bulletin T-5002R.

STEPPING SWITCHES. Fast and dependable. Bulletin T-5001R.

JACKS & PLUGS: For many electrical and electronic uses. Send for Bulletin T-5003.

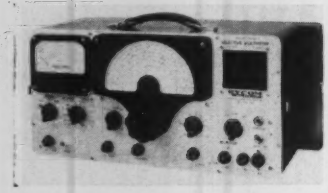
TELEPHONE HANDSETS: Standard or with switch assemblies. Send for Bulletin T-5017-R.

For bulletins and more information contact the nearest Sales Branch office: Atlanta—750 Ponce de Leon Place N.E.; Chicago—564 W. Adams Street; Kansas City (Mo.)—2017 Grand Avenue; Rochester—1040 University Avenue; San Francisco—1805 Rollins Road.

GENERAL DYNAMICS TELECOMMUNICATION

CIRCLE 138 ON READER-SERVICE CARD

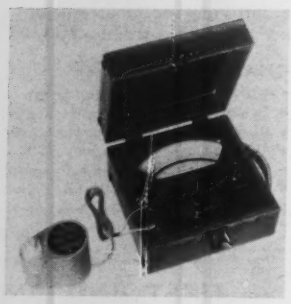
VOLTMETER



New Model 2173A Frequency-selective Voltmeter employs heterodyne principle with balanced modulation. Makes amplitude measurements between 3 kc and 2 Mc. Available with narrow crystal filter (250 cps) for amplitude measurements, and a wide crystal filter (2800 cps) with demoulator for monitoring single-side-band speech or tone signals.—*Rycom Instruments*, 9351 *E. 59St., Raytown* 33, *Mo.*

CIRCLE 421 ON READER-SERVICE CARD

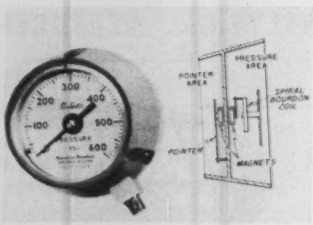
RF VOLTMETER



New thermocouple type Rawson-Lush RF Voltmeter used to calibrate RF VTVM's and to make precise RF Voltage measurements up to 100 Mc has accuracy better than 1% over total range and can be certified by NBS.—*Rawson Electrical Instument Co.*, 110 *Potter St., Cambridge* 42, *Mass.*

CIRCLE 422 ON READER-SERVICE CARD

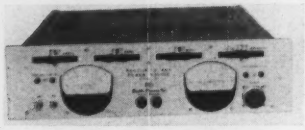
PRESSURE GAGES



New Model 5130 3½" high-performance gages eliminate hazard of gage glass explosions. Magnet attachment to spiral-wound Inconel-X Bourdon coil moves pointer through heavy cast-aluminum safety wall. Pressure range to 10,000 psi; accuracy ½%.—Technical Data Sheet 90-44.—*American-Standard Controls Div., Rochester Instrument Plant*, 100 *Rockwood St., Rochester* 10, *N. Y.*

CIRCLE 423 ON READER-SERVICE CARD

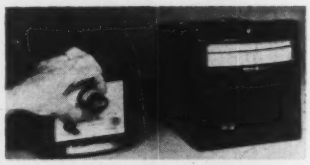
HI-VOLT DC SOURCES



Three new precision D-c Sources comprise Model 120, providing 20 ma in range of 500 to 2210 vdc; Model 122, with 20 ma from 0 to 3000 vdc, and Model 123, with 20 ma from 0 to 6000 vdc. Accuracies are 0.25% of any output voltage dialed; stability is 0.005%/hr; regulation vs line change, 0.01% for ±10% line; regulation vs load, 0.01% for 20 ma change; ripple less than 5 mv rms at any output voltage and current in either polarity.—*Smith-Florence, Inc.*, 4228—23*rd Ave., West., Seattle* 99, *Wash.*

CIRCLE 424 ON READER-SERVICE CARD

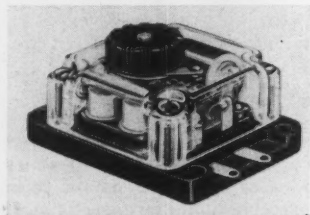
DIGITAL SET-POINT UNIT



New Type 510 Digital Set Point Unit for HP-30 series pyrometer controller uses a stable silicon diode voltage sources. Desired set point is selected in mv, corresponding to temperature, by use of digital dial and range suppression switch. Accuracy is ±0.25% of total span including linearity hysterisis; ±10% line voltage change, and ±10°C ambient temperature change. Ambient operating range is 0-140°F.—*General Electric Co., Schenectady* 5, *N. Y.*

CIRCLE 425 ON READER-SERVICE CARD

D-C AMPLIFIER

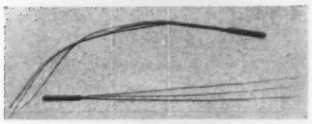


New self-contained Model 993 d-c Amplifier provides 10:1 amplification of inputs from photovoltaic cells below five foot-candles. Features include +2% linearity, on-off control for zeroing of moving-coil instrument, and pierced input and output terminals. Power is provided by 1.34-v mercury cell.—*Daystrom, Incorporated, Weston Instruments Div.*, 614 *Frelinghuysen Ave., Newark* 14, *N. J.*

CIRCLE 426 ON READER-SERVICE CARD

For More Information
Circle Corresponding Number
On Reader Service Card

TEMP TRANSDUCER



New tiny Temperature Transducer (1" lg x 1/8" OD), with tungsten or platinum sensing elements, has integral leads imbedded in glass or special high-temperature ceramic. Guaranteed accuracy is 0.1% of full range from -425° to 1750°F, linearity is high, hysteresis almost non-existant, response time less than 100 ms for 90% of final reading. Withstands shock of 100 G's at 11 ms, pressure from 0 to 5000 psi, vibration of 20 G's to 2000 cps.—*Temtro, Inc., 3016-C S. Halladay, Santa Ana, Calif.*

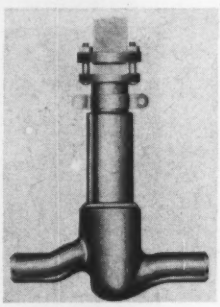
CIRCLE 427 ON READER-SERVICE CARD

MINI DC POT

New self-contained Model PC PocketPot fits palm of hand, has direct and "in-line" readout, 0.05% accuracy. Effective resistance is infinite at null. Measuring range is 0-5.100 v with continuous resolution over a 100-division slide wire (1 mv per division). — *Sensitive Research Instrument Corp., 310 Main St., New Rochelle, N. Y.*

CIRCLE 428 ON READER-SERVICE CARD

HOT HELIUM VALVE



New hot helium Valve, made either in solid body angle or globe pattern, features all-welded-construction bellow seals, auxiliary stuffing box, and vent connection. Sphere or knife edge seating assures minimum leakage even at 1600°F.—*Security Valve Co., 909 El Centro St., South Pasadena, Calif.*

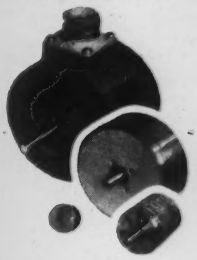
CIRCLE 429 ON READER-SERVICE CARD

Major eastern electronic manufacturer is seeking industrial representation for its line of pressure switches and transducers. Potential sales in the food processing, instruments and controls, petroleum and chemical, water and sewerage industries. Please write full particulars to Box #387.

How good is OPTISYN?

Here are some of the facts . . . you be the judge.

OPTISYN is an incremental shaft-angle transducer, capable of generating 2048 (or more) precisely-placed counting pulses per input shaft revolution in tiny Size 11 (1.1 inch case diam.); over 4000 counts per turn in larger sizes. OPTISYN has no gears, no sliding contacts. It can produce 100,000 reliable pulse counts per second, at shaft speeds up to 30,000 rpm! Counters have trouble keeping up with OPTISYN.



Sizes 11, 23, and 27 in growing OPTISYN line.

WHAT'S THE SECRET? OPTISYN is based on a unique OPTICAL GEARING principle that results in 4-times increase in resolution, dependable wide-aperture optics, and valuable error-averaging. Accuracy and reliability are the result. OPTISYN is standard equipment on Titan missile, offers 6 years mean-time-to-failure, and ruggedness to meet MIL-E-5272C.

VARIATIONS? Special designs, including pancake shapes, are in production for inertial accelerometers, gyro gimbals, pedestal mounts, industrial uses, etc. Output electronics also available to match high-performance OPTISYN into your digital system. Want more information?

DRC **DYNAMICS RESEARCH CORPORATION**

38 MONTVALE AVENUE STONEHAM, MASS.
Tel. 438-3900
Inertial and Industrial Control System Specialists

CIRCLE 139 ON READER-SERVICE CARD

COMPUTER ENGINEER

. . . to use analog simulation and computation techniques in the analysis of complete missile systems, VTOL aircraft, turbojet engines, space engines, advanced aircraft, as well as in advanced areas of physics such as particle trajectories.

Requires an ability to formulate technical problems and prepare circuit diagrams for modern, well-equipped, large scale analog computer facility. Up to five years experience is desirable, but not essential. A degree in engineering or physics is required.

Salaries are attractive as are the opportunities for professional development, early recognition, and fast personal growth.

Please write to Mr. W. W. Walsh

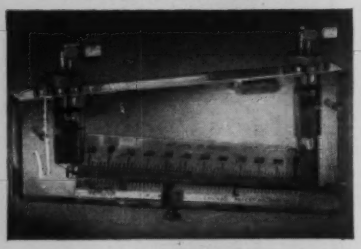
RESEARCH LABORATORIES
UNITED AIRCRAFT CORPORATION
East Hartford 8, Connecticut

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

FILTER EFFICIENCY

at a glance...

ANYTIME!



Dwyer

AIR FILTER GAGE

With the Dwyer Air Filter Gage you can be sure of maximum filter efficiency because you know the *exact* time to replace filters, *every time*. Gives a continuous, accurate check that spots inefficient filters, yet prevents waste through premature replacement.

The Dwyer measures filter efficiency the only practical and economical way—via pressure drop. Quickly pays for itself through savings in replacement and service time and greater operating efficiency.

Break-proof plastic construction, lifelong accuracy, simple installation, no moving parts to ever wear out or get out of adjustment. Ranges 0-½", 0-1", 0-2" and 0-3" water. A complete unit with all necessary tubing, fittings, etc.

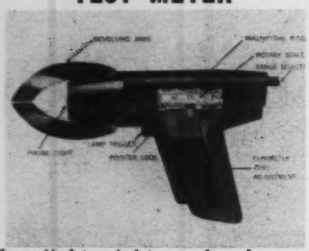
Write for Bulletin C10

F. W. DWYER MFG. CO.

P. O. Box 373-S • MICHIGAN CITY, IND.

CIRCLE 140 ON READER-SERVICE CARD

TEST METER



New lightweight one-hand-operable Pistolmeter measures current, voltages, resistance and tests circuits in inaccessible areas. Locking device on meter pointer affords readings after removing from tested conductor. Rotary scale has four current ranges (0-15/60/200/600 amp); two voltage ranges (0-150/600 v); and two ohmmeter ranges (0-500/5000 ohms). Furnished with test leads, battery charger, and holster.—*Federal Pacific Electric Co., 50 Paris St., Newark, N. J.*

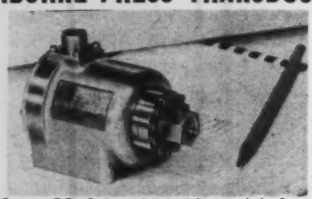
CIRCLE 430 ON READER-SERVICE CARD

PHOTOELECTRIC ENCODER

New Photoelectric Encoder converts barometric readings to digital information; has no contacts, slip rings, or magnetic reaction. Mated to a standard Kollsman altimeter setting indicator it can be driven directly by pressure mechanism. Transmits barometric pressure data in digital form from worlds first unattended nuclear weather station at a remote location north of the Canadian mainland.—*Kollsman Instrument Corp., Subs. of Standard Kollsman Industries, Inc., 80-08 45th Ave., Elmhurst 73, N. Y.*

CIRCLE 431 ON READER-SERVICE CARD

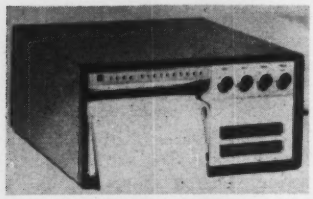
AIRBORNE PRESS TRANSDUCER



New Model 185/290-2 Airborne Pressure Transducer incorporating bonded-strain-gage transducer, solid-state amplifier, and voltage regulator measures corrosive liquid and gas pressures from 0-250 to 0-2000 psia or psig with 0.25% accuracy over a wide temperature range, produces 5-vdc (full scale) output signal to operate telemetering systems, servos, meters, or recording equipment. Measuring element is one-piece Ni-Span-C proving ring to which are bonded four active precision strain gages. Withstands severe accelerations and vibrations.—*Taber Instrument Corp., 107 Goundry St., North Tonawanda, N. Y.*

CIRCLE 432 ON READER-SERVICE CARD

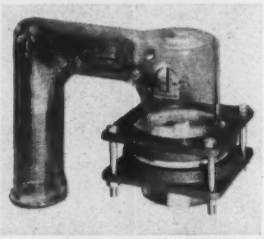
COMPACT OSCILLOGRAPH



New 24-channel direct-recording Model 1508 Visicorder can be rack mounted in 7" or is supplied in special case for table or bench use. Records individual static or dynamic phenomena on 8" paper at frequencies from dc to 5000 cps. Has 12 recording speeds with maximum in excess of 50,000 ips. Deflection of 8" peak to peak is possible.—*Minneapolis-Honeywell, Heiland Div., 5200 E. Evans Ave., Denver 22, Colo.*

CIRCLE 433 ON READER-SERVICE CARD

VACUUM BREAKERS



New line of spring-loaded corrosion-resistant Vacuum Breakers for chemical process industries consists of vertical-, side-, and top-mounting models for 1", 1½", 2", and 3" valve sizes. Available in stainless steel, Teflon-lined steel, or special materials.—*Chem Flow Corp., 117 Paterson Ave., Little Falls, N. J.*

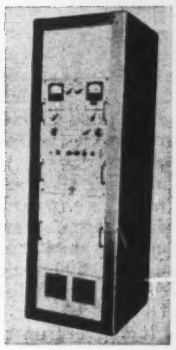
CIRCLE 434 ON READER-SERVICE CARD

DIGI ACQUISITION SYSTEM

New high-speed solid-state second-generation MicroSADIC Digital Acquisition system samples several hundred channels of analog data at up to 15,000 samples/sec. Converted to 4-place digital form, data are stored on magnetic tape or reproduced in printed form, or punched cards, or plotter. Operates in either binary-coded-decimal or binary mode.—*Consolidated Systems Corp., 1500 S. Shamrock Ave., Monrovia, Calif.*

CIRCLE 435 ON READER-SERVICE CARD

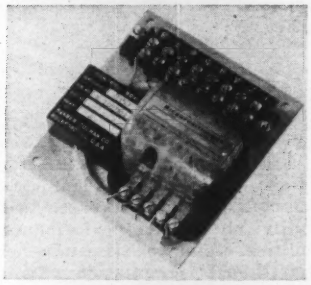
POWER SUPPLY



New Model CVC-300-6 constant-voltage and/or current Power Supply features automatic electronic changeover ideal for forming and aging of electrolytic capacitors and can be operated at either constant voltage (with adjustable current limiting) or constant current (with adjustable voltage limiting). With constant voltage, output range is 2-300 v and 0-6 amp. Line regulation is +0.1%; load regulation is +0.1%. —*NJE Corp., 20 Boright Ave., Kenilworth, N. J.*

CIRCLE 436 ON READER-SERVICE CARD

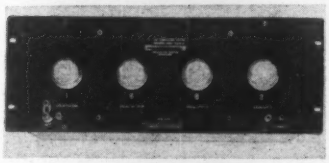
TEMP CONTROL SYSTEM



New heater cycling Temperature Control System for business aircraft maintains cabin temperature within ±2°F over wide range of varying altitude and ambient temperature conditions. Based on resistance bridge circuit with ultra-sensitive polarized relay as bridge unbalance detector. Bulletin.. F-10610.—*Barber-Colman Co., Rockford, Ill.*

CIRCLE 437 ON READER-SERVICE CARD

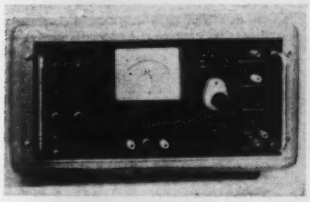
DECADE CAPACITORS



New Decade Capacitors include (1) 4-dial Type 1423-A precision model (illustrated) with in-line readout; 11,110 discrete values of capacitance in steps of 100 pf between 100 pf and 1.111 μf and accuracy of ±0.05%. (2) Type 1424-A standard model which provides standard values of capacitance from zero to 10 μf, and (3) Type 1419-B with four individual polystyrene capacitors, accurate to —1%.—*General Radio Co., West Concord, Mass.*

CIRCLE 438 ON READER-SERVICE CARD

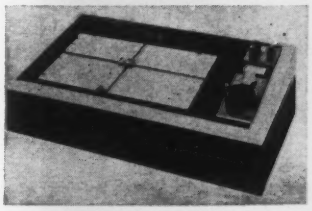
ELECTRONIC POTENTIOSTAT



New Potentiostat for the investigation of phase boundaries between an electrolyte and a metal regulates current in an electrochemical cell from a reference electrode to a measuring electrode. Used for corrosion research, in interface chemistry, etc. Bulletin.—*Brinkmann Instruments, Inc., 115 Cutter Mill Rd., Great Neck, N. Y.*

CIRCLE 439 ON READER-SERVICE CARD

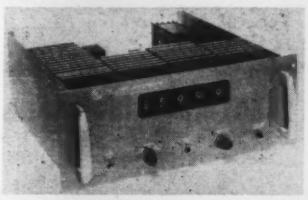
SERVO RECORDER



New HR-87 T-Y Recorders eliminate inconvenience of handling and cutting rolls of chart paper and of replotting data. Records on standard 11" x 16½" graph paper immediately available. Several parallel records can be run on one chart for comparison. Bulletin.—*Houston Instruments Corp., Box 22234, Houston 27, Tex.*

CIRCLE 440 ON READER-SERVICE CARD

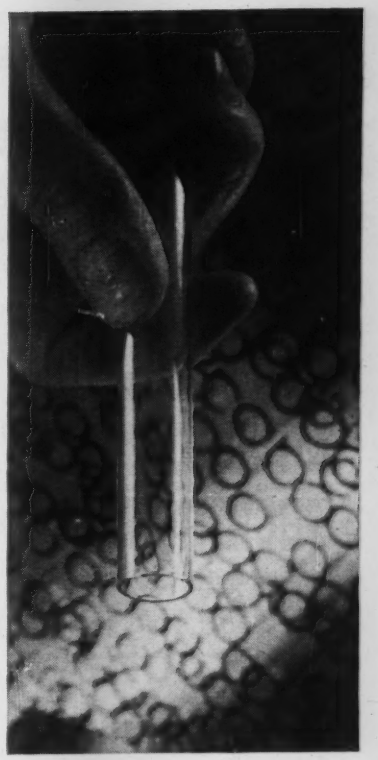
SHAFT ANGLE TRANSLATOR



New EECO-780 Shaft Angle Translator produces visual display and BCD data outputs from translation of shaft-encoded input signals, reads angles instantly with 0.01° resolution. Accepts up to 16 Gray or binary-coded digits from brush or photo-optical types of shaft encoders.—*Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.*

CIRCLE 441 ON READER-SERVICE CARD

For More Information on Products Listed Please Circle the Corresponding Number on Reader-Service Card



THIS TUBING CAN SAVE YOU MONEY

This special CORNING® flint glass tubing and rod give you ease of forming, strength, and topflight transparency. They are priced up to 50% lower than PYREX® tubing and rod. They are available immediately.

We developed CORNING brand 0088 flint glass just for the making of low-temperature-service tubing and rod. In uses near room temperature, it resists chemicals almost as well as PYREX brand glasses.

A statistical profile: coefficient of expansion, 92 x 10^{-7}; softening point, 700°C.; annealing point, 521°C.; strain point, 480°C.

We put this glass into apparatus tubing with outer diameters which range from 3 to 51 mm, in capillary and barometer tubing with inner diameters from 0.5 to 4 mm, and in rod with diameters from 3 to 12 mm. All are furnished in 48-inch lengths.

You can get any type in any quantity, quickly. For information on our entire tubing and rod line, write for Bulletin TBG-88.

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10011 Crystal St., Corning, N. Y.
CORNING MEANS RESEARCH IN GLASS

CIRCLE 141 ON READER-SERVICE CARD

TEMPERATURE MEASUREMENT TECHNIQUES TODAY are more advanced, too!

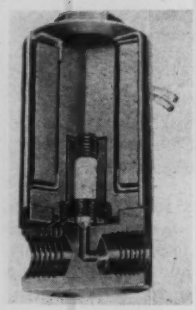
NEW Thermo-Ref by Genistron represents the most modern method

The Space Age design and solid-state reliability of Genistron's Thermo-Ref Thermocouple Reference **completely outdates older type electric "hot" temperature reference techniques, and particularly ice bath methods.** Thermo-Ref applies latest electronic design to achieve miniaturization ideal for modern airborne and other aero/space applications. Retains the high accuracy available to ±0.05°C. usually possible only in an expensive laboratory environment. Isolation—channel-to-channel as well as each-channel-to-case—exceeds 100 megohms. Other exceptional features include low power consumption (1 watt nominal), high stability, maintenance-free construction. Available in airborne and ground units with various temperature references. Complete information available on request to:

Genistron
A Subsidiary of Genisco Inc.
6320 WEST ARIZONA CIRCLE
LOS ANGELES 45, CALIFORNIA

CIRCLE 142 ON READER-SERVICE CARD

MINI SOLENOID VALVE



New 600-Series miniaturized 2-way, N-C Solenoid Shutoff Valve features unique actuating principle which opens poppet even against operating pressures to 3000 psi, 1/16" dia orifice, explosion-proof case, and bubble-tight sealing characteristic.—*Circle Seal Products Co., Inc.*, 2181 *E. Foothill Blvd., Pasadena, Calif.*

CIRCLE 442 ON READER-SERVICE CARD

BATTERY ELIMINATOR

New Battery Eliminator and Charger 1064, delivers undistorted dc for servicing transistorized equipment by using special L-C filter circuit. Features include: two d-c voltage ranges, simultaneous monitoring of both voltage and current on both ranges, separate voltmeter and dual-range ammeter, extra heavy-duty selenium rectifiers.—*EICO Electronic Instrument Co., Inc.*, 33-00 *Northern Blvd., Long Island City* 1, *N. Y.*

CIRCLE 443 ON READER-SERVICE CARD

ELECTRICAL INDICATOR

New 740-series of 2½" moving-magnet Meter for dc, available as milliammeter, ammeter, or voltmeter in all popular ranges features polystyrene case, long 1¾" scale, easy readability. Horizontal U-clamp mounting is standard.—*Hoyt Electrical Instrument Works, Inc., Burton-Rodgers Co.*, 42 *Carleton St., Cambridge* 42, *Mass.*

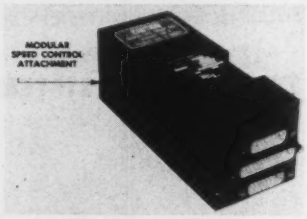
CIRCLE 444 ON READER-SERVICE CARD

REGULATOR

New 2¼"-high and 1 7/8"-wide Banti-Reg Model 2017 Pressure Regulator with gage port (Model 2018 without gage port) is made of all brass with neoprene diaphragm. Primary pressures up to 400 psig can be regulated to 5-125 psig secondary pressures. It delivers up to 80 cfm (±1°) at 100 psig with 200 psig inlet pressure.—*Wilkerson Corp.*, 1605 *W. Mansfield, Englewood, Colo.*

CIRCLE 445 ON READER-SERVICE CARD

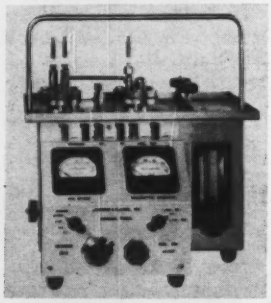
MOTOR SPEED CONTROL



New Speed Control transistorized modular attachment to rotary switches for precision control of 28-dc input performs function of mechanical governor, but provides increased life, reliability, and higher performance capabilities. Motor speeds can be held to better than 2% regulation with input voltage variations of ±10% from −55° through 100°C.—*Instrument Development Labs., Inc.*, 67 *Mechanic St., Attleboro, Mass.*

CIRCLE 446 ON READER-SERVICE CARD

OXYGEN ANALYZER



New Portable Laboratory Trace Oxygen Analyzer Model L for determining trace quantities of oxygen in argon, nitrogen, helium, methane, ethylene, hydrogen, and carbon dioxide has operation based on a coulometric process in which oxygen is quantitatively reduced in pores of silver electrode. Three basic ranges: 0-20, 0-100, and 0-1000 ppm O_2 by volume. When used with recorder, range may be decreased to 5 ppm or less. Battery-operated, weighs 30 lb.—*Lockwood & McLorie, Inc., Box* 113, *Horsham, Pa.*

CIRCLE 447 ON READER-SERVICE CARD

FUSED QUARTZ SPRING ENGINEERING KIT

$35.00

A complete kit of quartz products containing:

- 6 helical springs with hooks on ends, for maximum loads of 50, 100, 500 milligrams and 1, 2, and 5 grams, extensions of 75 mm.
- 1 flat spiral spring with torque of 200 dyne cm./radian
- 1 fused quartz sample pan (hemispherical)
- 1 assortment of straight quartz fibers in sizes 25 to 500 microns diameter

Also available—sample spring kit with 5 quartz springs similar to above $25.00.

Designers and manufacturers of special quartz measuring systems, microbalances for very precise measurements in sealed systems, quartz bourdon tubes for pressure measurement.

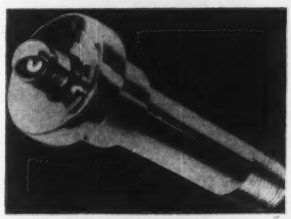
Write for quartz products bulletin.

WORDEN LABORATORY

695 Rocky River Road, Houston 27, Tex.

CIRCLE 143 ON READER-SERVICE CARD

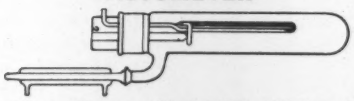
SONIC ENERGY GENERATOR



New SoniJet high-frequency Sonic Energy Generator uses shock-wave method of foam destruction in chemical and petrochemical processes. Operates by compressed air.—*Kearfott Div., General Precision, Inc.*, 1150 *McBride Ave., Little Falls, N. J.*

CIRCLE 448 ON READER-SERVICE CARD

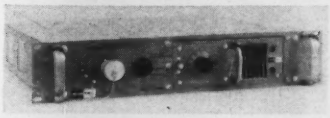
VISCOMETER



New all-glass Model JU-2 Zeitfuchs Universal Viscometer for kinematic-viscosity measurements on transparent or opaque liquids is of the reverse flow type, has no drainage correction. Only one run can be made on a single filling. Range is 0.6 to 360,000 centistokes. Has boiling jacket and condenser for high-temp use. Bulletin.—*Spira Glass*, 12 *Summit Lane, Berkeley* 8, *Calif.*

CIRCLE 449 ON READER-SERVICE CARD

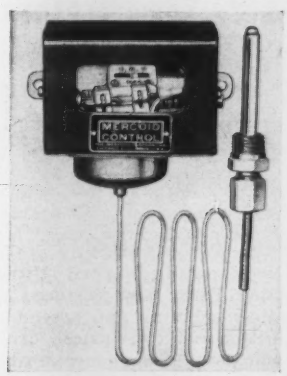
PREAMPLIFIER



New AC/DC Preamplifier 458 C/N is a chopper-stabilized, single-ended, wideband d-c amplifier with front panel controls providing four modes of operation: (1) d-c gain of −100 with ±0.01% gain accuracy and 0.3 cps bandwidth, (2) gain of ±1 with greater than 10,000 megohms input impedance and ±0.001% d-c gain accuracy, (3) wideband gain of −100 providing ±0.1% accuracy from dc to 2 kc, and (4) nine wideband gain steps of −20 to 1000 providing ±1.0% gain accuracy and a 40 kc bandwidth.—*Kin Tel Div., Cohu Electronics, Inc.*, 5725 *Kearny Villa Rd., San Diego* 12, *Calif.*

CIRCLE 450 ON READER-SERVICE CARD

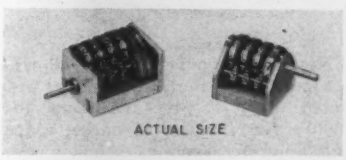
TEMPERATURE CONTROL



New Type AT-153 Mercoid Temperature Control for air conditioning, freeze protection, refrigeration, etc. is small (4 1/8" x 4 7/16" x 2 7/8"), features external adjustment, repetitive trip point, visible calibrated dial with pointer, visible on/off hermetically-sealed mercury contact. Bulletin 0-28.—*Mercoid Corp.*, 4201 *Belmont Ave., Chicago* 41, *Ill.*

CIRCLE 451 ON READER-SERVICE CARD

SUBMINI COUNTERS



New reversible Subminiature Counters have 0.288" dia drums with digits 0.075" x 0.045" wide. Model 1005 has a 200 to 1 gear reduction, 120-pitch gears, 7/16" x 5/8" x 29/64", maximum input speed 5,000 rpm. Model 1006 is 7/16" x 15/32" x 29/64".—*Haydon Instrument Co.*, 17 *Brown St., Waterbury* 20, *Conn.*

CIRCLE 452 ON READER-SERVICE CARD

Genisco

*apd

ANALOG TO PULSE DURATION INSTRUMENTATION

HERE'S THE FIRST SMALL COMPLETE DATA-ACQUISITION SYSTEM

The new low-cost Genisco APD Data Acquisition system is a complete and compact solid-state packaged system designed to meet a wide range of instrumentation requirements. You can use it to read out thermocouples, resistance thermometers, strain-gage transducers or any other DC voltage low-impedance sensors. Modular plug-in board design allows great flexibility—one chassis can provide a complete 20-channel system.

Data is sampled at 20 samples per second; repeatability is 0.1% of full scale. Output can be shown or recorded directly in engineering units with sign indication and channel identification. Readout can be converted to punch tape, magnetic tape, typewriter or other storage medium.

The new Genisco APD requires low power and is ideal for portable, laboratory, or field use. Call or write today for prices and complete details.

*Patent Applied For

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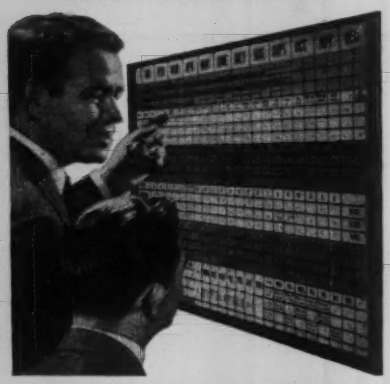
CIRCLE 144 ON READER-SERVICE CARD

How To Get Things Done Better And Faster



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- ☆ Simple to operate—Type or Write on Cards, Snap in Grooves
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. . . read directly on a counter!

CARSON-DICE AUTOMATIC Electronic Micrometer

Accurate! The Carson-Dice Micrometer permits measurement to 10 millionths on any part or material, hard or soft, fragile or compressible.

Foolproof! Model PDR (shown) eliminates operator discrimination, measures with O-pressure on conducting parts . . . or standard reference pressures of 1.5, 5, 10, and 20 grams on conductors or non-conductors.

FAST! Unexcelled for high-speed readings on close tolerance precision parts, semi-conductors, deposited films, grids, coated cathodes, diaphragms, wire.

Address inquiries (and submit your measurement problems) to:

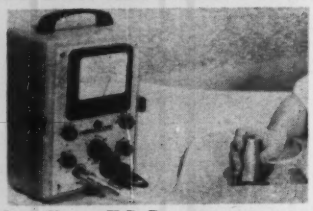
J. W. DICE CO.

Englewood 10, N. J.

LOwell 9-0471

CIRCLE 146 ON READER-SERVICE CARD

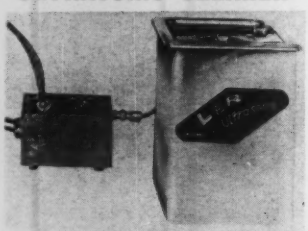
NON-DESTRUCTIVE TESTING



New Type EC Permascope non-destructive Testing Device accurately gages non-conductive coatings on aluminum and its alloys, measures thicknesses of a non-ferrous metal on a non-ferrous base, non-ferrous coating on a non-conductor, and conductivity of non-ferrous metal. 9" x 6½" x 6½". Operates from 110-vac outlet on eddy-current test principle. Electronic circuitry allows compensation for conductivity variations of base metal which would otherwise produce erroneous readings.—*Twin City Testing Corp., 533 South Niagara St., Tonawanda, N. Y.*

CIRCLE 453 ON READER-SERVICE CARD

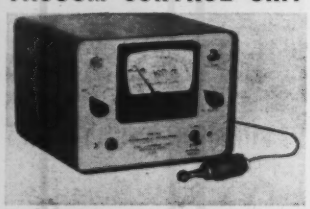
ULTRASONIC CLEANER



New transducerized Ultrasonic Cleaning Tank, now produced by automatic machining and assembly line production and lower priced, draws ultrasonic power from generator base of L & R Master, Mastermatic, or Vari-Matic Cleaning Machines. 5" x 5¾" x 6" with stainless-steel cover, it weighs nine lb.—*L & R Mfg. Co., Kearny, N. J.*

CIRCLE 454 ON READER-SERVICE CARD

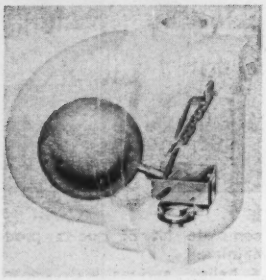
VACUUM CONTROL UNIT



New Protectovac Type 0745 which automatically maintains any preselected level of pressure from 40 to 1000 μ for vacuum furnaces, coaters, and pumping systems reads a signal from Type 521 thermocouple gage and opens and closes 5 amp contacts at selected pressure point. Contacts operate external circuits to control power, run diffusion pump, sound alarm or turn on signal lights, and open or close valves.—*NRC Equipment Corp., Subs. of National Research Corp., 160 Charlemont St., Newton 61, Mass.*

CIRCLE 455 ON READER-SERVICE CARD

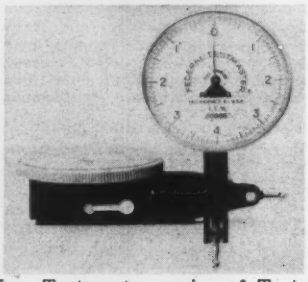
THERMOSTATIC STEAM TRAP



New Float Thermostatic Steam Trap features indestructible stainless steel bi-metal thermostatic air vent, unique rocker design with no pivots to wear. Pressure ranges 0-30; 0-75; 0-150 psi.—*Farris Engineering Corp., 610 Commercial Ave., Palisades Park, N. J.*

CIRCLE 456 ON READER-SERVICE CARD

TEST INDICATORS



New Testmaster series of Test Indicators has 40% less gaging tension and 25% less friction than previous models due to more responsive internal mechanism plus introduction of new counter-balanced indicating hand and full-jeweled bearings. Made with 1½" and 1" dials.—*Federal Products Corp., Providence, R. I.*

CIRCLE 457 ON READER-SERVICE CARD

DC POWER SUPPLY

New high-stability high-voltage D-C Power Supply HSV-5-20 features stability of ±0.005%/hr (±0.02% for an eight-hour period) has output of 50 to 5,000 v and 0-20 ma. Input power is 105-125 v at 55-65 cps. Maximum ripple is 5 mv peak-to-peak. Static regulation is 0.01% maximum load for no-load to full-load change at constant voltage, and 0.01% maximum line for line voltage change of 105-125 vac at any constant load from zero to full load of rating. Dimensions: 8¾" x 19" x 18¼".—*NJE Corp., 20 Boright Ave., Kenilworth, N. J.*

CIRCLE 458 ON READER-SERVICE CARD

MICO

Heavy-Duty 2 & 3 Dimensional Engraver

FOR:
Engraving Nameplates
Fine Routing Work
Profiling Small Objects
Making Small Dies and Molds

FEATURES OF NEW ENGRAVER

1. Six Reduction Ratios—From 1.5:1 to 4:1.
2. Heavier bearings in micrometer spindle.
3. New 1/10 H.P. Ball Bearing Motor permits continuous operation for die or mold work in steel.
4. Absolute accuracy for three-dimensional reproduction.
5. Uses standard taper-shank cutters or ⅛" diameter straight shank cutters and end mills.
6. Copy and work right-side-up: always in direct view of operator.
7. Many attachments available to increase versatility of machine.

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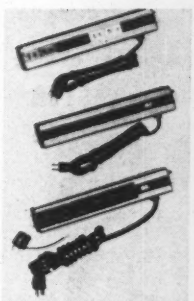
CIRCLE 147 ON READER-SERVICE CARD

POWER CONTROLS



New Models 20CB, 24CB, and 30CB in line of master Power Controls feature "push-to-reset" circuit breakers instead of fuses. Rated at 15 amp/130 v, they feature heavy-duty line cords, drawn metal case, mounting ears, and nylon strain relief.—*Waber Electronics, Inc., Hancock and Somerset Sts., Phila. 33, Pa.*

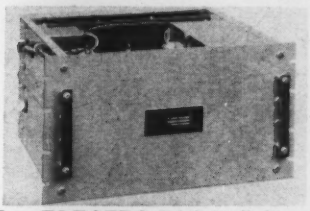
CIRCLE 459 ON READER-SERVICE CARD

DESK THERMOSTAT

New Desk Thermostat is for heating and/or cooling applications, has direct control action, ½° F response, 60° F to 85° F range, ±1° F accuracy. —*Powers Regulator Co., 3400 Oakton St., Skokie, Ill.*

CIRCLE 460 ON READER-SERVICE CARD

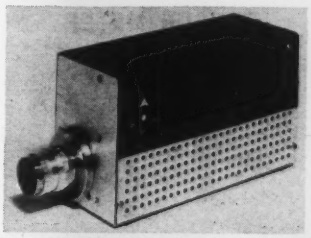
STANDBY POWER SYSTEM



New ELECTRO-PAC "A" Standby Power System cuts in with zero switchover time when a-c line drops below pre-set level. Provides a-c from battery source, regulating voltage to ±7% with 3% maximum harmonic distortion in the sine wave output produced by this solid state device. Bulletin.—*Electrol-Seal Corp., 938 North Ave., Des Plaines, Ill.*

CIRCLE 461 ON READER-SERVICE CARD

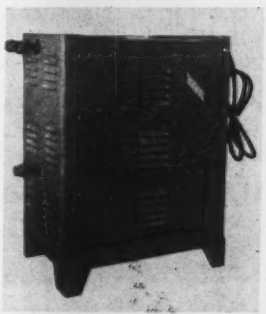
VIDICON CAMERA



New V-945 Camera delivers 700-line horizontal, and 650-line vertical resolution at 1[illegible] foot-candles reflected light. Camera voltages are regulated. Control unit available in rack or cabinet mount.—*Amer. Microwave and Television Corp., San Carlos, Calif.*

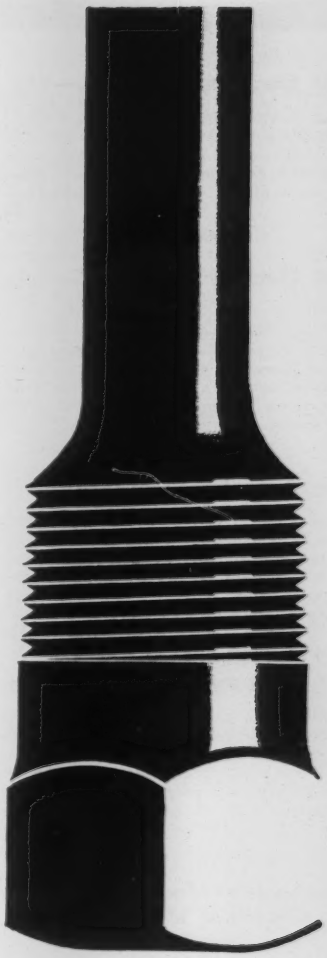
CIRCLE 462 ON READER-SERVICE CARD

AIR DRYER



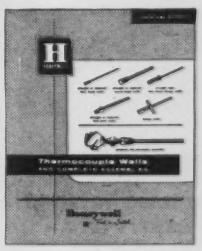
New Model 250AD Refrigerated Compressed Air Dryer dehumidifies 25 scfm of 100-psig air to dew point of −12°F (atmospheric). Input air (directly from air-compressor tank up to 150 psig) is cooled to slightly above freezing and moisture is removed through automatic discharge trap. "Thermal-Mass" type heat exchanger has refrigerant and air coils surrounded by special heat conductive material of considerable mass whereby substantial flow of compressed air through exchanger results in only small temperature rise in exchanger medium.—*Zeks Industries, Inc., Edgemont, Pa.*

CIRCLE 463 ON READER-SERVICE CARD



THERMOCOUPLE WELLS

Nine basic types of standard pressure-tight wells, with or without T/C assemblies, and any type of special wells made to order. All are beta-gage checked for concentricity. Thermocouple wells are among thousands of accessories—all available from a single dependable source—that can help your instruments perform at their very best.



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CIRCLE 148 ON READER-SERVICE CARD

For Your Library

100 Electronic Circuits—Vol. 1

by M. H. Aronson and C. F. Kezer . . . covers amplifiers, oscillators, pulse circuits, phase shifters, etc. Complete with all circuit component values and response specifications. Paper, 180 pages, 1957 **$2.00**

100 Electronic Circuits—Vol. 2

Second in the series by Aronson and Kezer, Vol. 2 also gives complete values and specifications for 100 "new" circuits not covered in Vol. 1. Complementing each other perfectly, the two volumes become a powerful circuitry design tool. Vol 2, Paperbound, 1960. **$2.00**

The Automatic Factory

by June, et al . . . a fresh viewpoint on what "manless factories" can be . . . free from the generalities, and misconceptions so prevalent on this subject. Cloth, 88 pages, 1955. **$1.50**

Nuclear Reactors for Industry and Universities

edited by E. H. Wakefield. The several distinguished authors and editor Wakefield cover types, availablity (1954), operation, protection, control, experiments, legal aspects, and present a detailed cost study. Cloth, 92 pages, illustrated, 1954. **$2.00**

Mechanical Measurements by Electrical Methods

by H. C. Roberts . . . describes gaging methods based on variations of capacitance, inductance, resistance, as well as photoelectric piezoelectric, thermoelectric, acoustic, and other methods . . . covers principles of bridge and potentiometer circuits, plus required and available equipment. Second edition, cloth, 368 pages, 1951. **$2.00**

Applications of Industrial pH Controls

by A. L. Chaplin. "pH is a concentration variable which responds to and is a measure of the effects of a chemical reaction . . . and follows a non-linear control relationship" presenting unique problems in pH control application. Clothbound, 144 pages, 1950. **$2.00**

Heat Inertia Problems of Automatic Control of Temperature

by Victor Broida . . . "fictitious mass" concept of heating process unit under automatic control. Paper, 61 pages, 1950. **$1.00**

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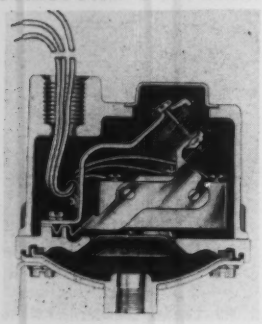
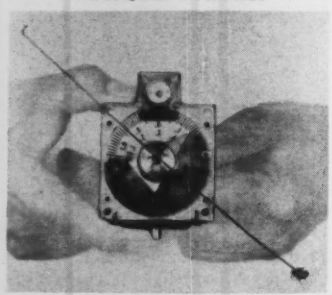
PRESSURE SWITCHES



New Diaphragm Pressure Switches with instrument accuracy of ±½% are made into basic models with test pressure ranges 10-300 psi, 6" to 30" vac. Bulletin 610601.—*Barksdale Valves, Pressure Switch Div.*, 5125 *Alcoa Ave., Los Angeles* 58, *Calif.*

CIRCLE 464 ON READER-SERVICE CARD

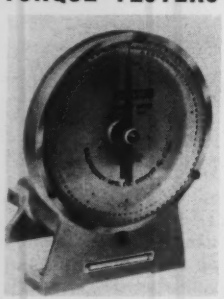
TORQUE METER



New 781 GM-CM Torqmeter measures rotating torques of miniature servo motors, gyros, and hairsprings. Full scale ranges are 1, 2 and 5 gm-cm, and 3% accurate readings are possible from 0.1 to 5 gm-cm at speeds up to 10,000 rpm. Made of clear, molded plastic.—*Power Instruments, Inc.*, 7352 *North Lawndale Ave., Skokie, Ill.*

CIRCLE 465 ON READER-SERVICE CARD

TORQUE TESTERS



New series of compact Torque Testers is for all types of hand-operated torque wrenches and torque limiting screwdrivers. Four models feature combination scales calibrated in inch-ounces and inch-pounds or foot pounds and inch-pounds from 0.800 in-oz through 0-1000 ft-lb. Built on torsion-bar principle.—*B. K. Sweeney Mfg. Co.*, 6300 *E. 44 Ave., Denver*, 16, *Colo.*

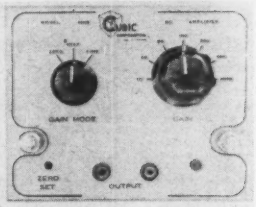
CIRCLE 466 ON READER-SERVICE CARD

PROVING RING

New Proving Ring can measure compression forces up to 1,200,000 lb to accuracies well within 1/10% of applied load. 30½" high, weighs 625 lb.—*Morehouse Machine Co.*, 1742 *Sixth Ave., York, Pa.*

CIRCLE 467 ON READER-SERVICE CARD

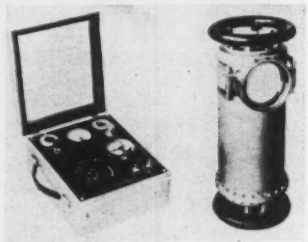
DC WIDEBAND AMPLIFIER



New DC Wideband Amplifier Model 1010 provides full magnetic and electrostatic shielding, solid-state amplifier circuitry, extremely low noise characteristics, gain accuracy of 0.1% at fixed gain settings of 10, 20, 50, 100, 200, 500, and 1000.—*Cubic Corp.*, 5575 *Kearny Villa Rd., San Diego* 11, *Calif.*

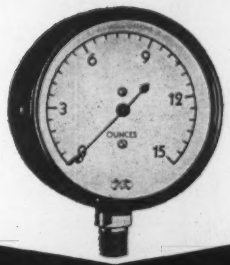
CIRCLE 468 ON READER-SERVICE CARD

INDUSTRIAL X-RAY TESTER



New Baltospot 150 150-KVP Industrial X-Ray Unit provides low cost inspection for metals ranging from wafer-thin magnesium to 1⅝" thick steel or its equivalent. Features include: shockproof weather resistance construction for continued outdoor or indoor use, end-positioned ports for easy access to areas with minimum inside diameter of 19". Model 4251, for directional beam radiography, has wide-angle, 60° X-ray tube, Model 4254 has 360° tube for circumferential radiography.—*Westinghouse Electric Corp., Industrial X-Ray Dept.*, 2519 *Wilkens Ave., Baltimore* 3, *Md.*

CIRCLE 469 ON READER-SERVICE CARD



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DIAPHRAGM GAUGES

for accurate pressure measurement in ounces or inches of water

Standard dials reading in inches of water, ounces, centimeters or millimeters up to 10 P.S.I. All Marshalltown diaphragm gauges are extremely sensitive and accurately measures very low pressures.

Let Marshalltown answer your gauge problems . . . write for information and prices.

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A Subsidiary of The Electric Autolite Company
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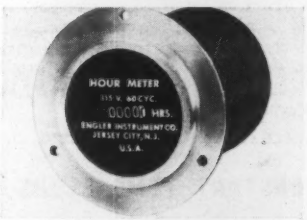
CIRCLE 149 ON READER-SERVICE CARD

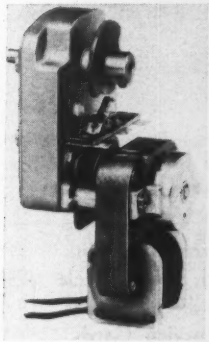
AC HOUR METERS



New line of A-C Hour Meters covers voltage range 110 to 550 v/60 cps. 2-7/64" dia, completely accurate, large figures, sealed in dehumidified case.—*Engler Instrument Co.*, 250 *Culver Ave., Jersey City* 5, *N. J.*

CIRCLE 470 ON READER-SERVICE CARD

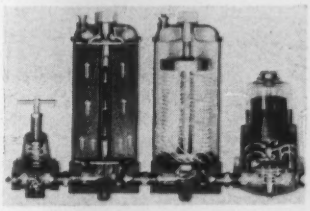
DAMPER CONTROL



New Damper Control Gear Motor incorporates cam, switch and brake, is automatically energized when blower is turned on.—*Brevel Products Corp.*, 643 *W. 26th St., New York* 1, *N. Y.*

CIRCLE 471 ON READER-SERVICE CARD

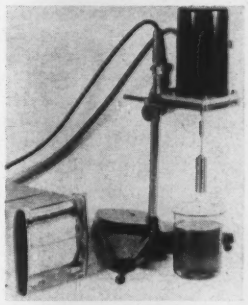
AIR DEHYDRATOR



New compressed-air Dehydrator is rated 10 scfm max at 100 psi, can lower dew point to -100°F, and removes oil to 2 ppm. Does not require draining as first stage of unit has moisture separator with built-in automatic sump-drain mechanism. Requires no electrical or water connections. Desiccant is visible in dehydrator through transparent shell.—*Wilkerson Corp.*, 1605 *W. Mansfield, Englewood, Colo.*

CIRCLE 472 ON READER-SERVICE CARD

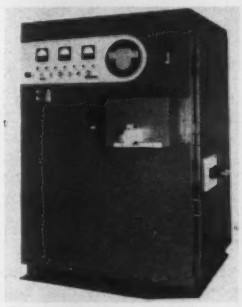
VISCOMETER



New portable explosion-safe Brookfield Rheolog for continuous laboratory indicating and recording of viscosity is direct reading in centipoises. Determines non-Newtonian properties such as pseudo-plasticity, plasticity, and dilatancy and obtains flow curves of thixotropic, rheopetic, time-dependent and temperature-dependent materials. Bulletin RL 100.—*Viscosel Corp., Box* 240, *Stoughton, Mass.*

CIRCLE 473 ON READER-SERVICE CARD

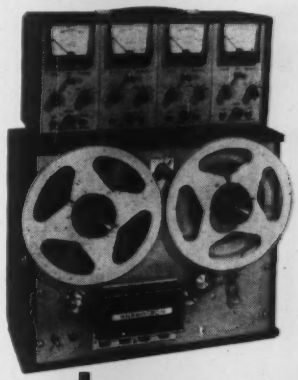
VARIABLE RF GENERATOR



New Ther-Monic variable-frequency Generator has 10-kw output in 3-to-22-Mc range divided into three bands (3-6, 6-12, and 12-22 Mc). For heating of alloys, zone refining, and alloy dispersion in semi-metals; etc.—*Induction Heating Corp.*, 183 *Wythe Ave., Brooklyn* 11, *N. Y.*

CIRCLE 474 ON READER-SERVICE CARD

data recorders expensive?



not any more

now, Mnemotron gives you a complete, easy-to-use 4-channel analog tape record/reproduce system with 0.2% precision for only $3,495

Complete with 10½" reel tape transport, rack mounted

Mnemotron offers a unique pulsed FM principle and fully transistorized, self-contained unit that records all analog • data • data acquisition • programming • computer read IN and read OUT • dynamic simulation. With Mnemotron, you can do more with paper recorders . . . expanding frequency response and channel capacity, saving you from being deluged with data, permitting you to look at the same data at different time scales.

Model M204 features:
Any 2 adjacent speeds: 3¾, 7½, 15 ips. Added low speed available on special order.
• storage, analysis and reduction • time scale contraction and expansion

Frequency Response:
- DC—800 cps @ 15 ips
- DC—400 cps @ 7½ ips
- DC—200 cps @ 3¾ ips

Linearity: 0.2% full scale.
Noise: Less than —50 db full scale.
Crosstalk: Below 70 db.
Extended range systems also available.

Write, wire, phone today for complete details.

MNEMOTRON CORPORATION

precision analog data tape recorders and biological computers
41 South Main Street, Pearl River, N. Y.
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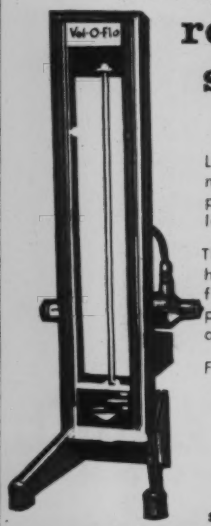
• Cables: Mnemotron

CIRCLE 150 ON READER-SERVICE CARD

Vol-O-Flo®
meters flowing gases accurately reliably simply



Laminar flow elements give highest possible accuracy, linear scale.

This type flowmeter has proved itself for laboratory, plant, field test, and OEM use.

Full Scale Ranges: Min., 20 cc/min. Max., 300 CFM

Specials Available

Request Bulletin 153 and blank specification sheet.

NATIONAL INSTRUMENT LABORATORIES, Inc.
828 EVARTS ST., N.E., WASHINGTON, D. C.

CIRCLE 151 ON READER-SERVICE CARD

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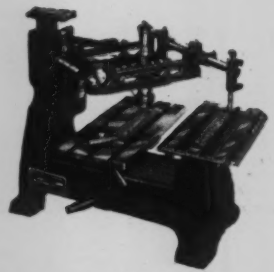
WHAT'S YOUR ENGRAVING PROBLEM
There's a Model to solve all your problems. Preis is the "one source" solution for your engraving problems. Complete line of accessories and attachments are available for all makes and models.

- Need greater speed for engraving light and medium characters use Preis-Panto Model UE-2.
- Does work require heavy duty machines use Preis-Panto Model UE-3.
- Marking metal of extreme hardness, electrical or diamond drag use Preis-Panto Model UE-M or UM.
- Preparing hardened steel or glass for acid etching ask for Preis-Panto Model UA-M.



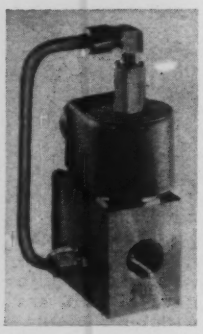
TRADE MARK PANTO

Write for complete details and prices. For immediate attention write directly to manufacturer below. Ask for nearest representative.

H. P. PREIS ENGRAVING MACHINE CO.
661 U. S. Highway 22, Hillside, N. J.

CIRCLE 152 ON READER-SERVICE CARD

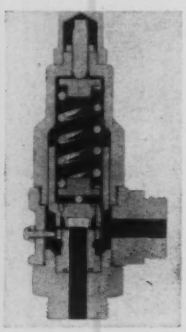
HI PRESS SOLENOID VALVE



New 2-way high pressure Solenoid Valve particularly for hydraulic applications is of N-O construction, operates at pressures to 1000 psi air, 850 psi water and light oil. ½" NPT with brass body and integral seat, and composition disc. Bulletin 8223.—*Automatic Switch Co., Florham Park, N. J.*

CIRCLE 475 ON READER-SERVICE CARD

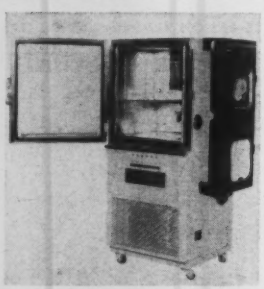
HI PRESS RELIEF VALVES



New Relief Valves for liquid or gas service to 5000 psi feature a resilient flat seated nylon disc with guided lift design maintaining a leakproof seal, and adjustable blowdown ring. Pressure ranges: 300-1000 psi, 1000-3000 psi, 3000-5000 psi, with ½" or ¾" end connections for liquids or gases at temperatures −20°F to 275°F.—*Combination Pump Valve Co.*, 848 *Preston St., Phila.* 4, *Pa.*

CIRCLE 476 ON READER-SERVICE CARD

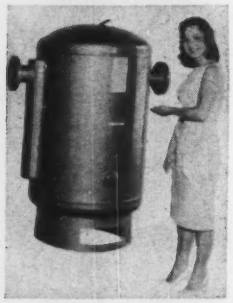
ENVIRONMENTAL TEST UNIT



New Tenney-Mite TH Model TM-TH0200 temperature-humidity Test Unit with 5.1-cu-ft test space for MIL-Spec testing provides temperatures 0° to 200°F and relative humidity from 20% to 95% in the dry bulb range, limited only by +35° to +185° dew point, pull-down from +70° to +200°F in approx. 1 hr. Exterior measures 26" x 62" x 33".—*Tenney Engineering, Inc.*, 1090 *Springfield Rd., Union, N. J.*

CIRCLE 477 ON READER-SERVICE CARD

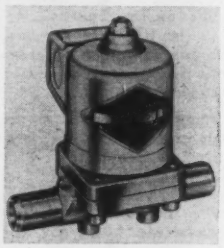
AIR DRYERS



New redesigned Dryers for compressed air systems features easier installation by placing inlet and outlet connections directly opposite each other, new air flow principle.—*General-Erie*, 1702 *Peninsula Dr., Erie, Pa.*

CIRCLE 478 ON READER-SERVIC CARD

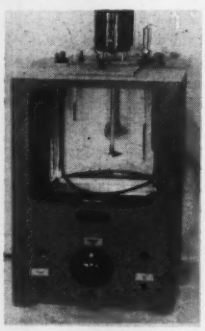
SOLENOID VALVES



New N-O Solenoid Valves, specifically for refrigerants 12, 22, and 500, have a-c or d-c waterproof epoxy-clad coils, are available in port sizes ¼" to 1¼", with either pipe or sweat connections. Remain open denergized.—*Jackes-Evans Mfg. Co., Controls Div.*, 4427 *Geraldine Ave., Saint Louis* 15, *Mo.*

CIRCLE 479 ON READER-SERVICE CARD

CONSTANT TEMP BATHS

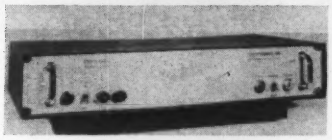


New Constant-temperature Baths made in 9 models for ±0.01°C and ±0.001°C feature mechanical refrigeration and full view window with internal illumination. Both electronic relay and resistance-thermometer electronic bridge controls available.—*Bayley Instrument Co., Box* 538, *Danville, Calif.*

CIRCLE 480 ON READER-SERVICE CARD

For More Information on Products Listed Please Circle the Corresponding Number on Reader-Service Card

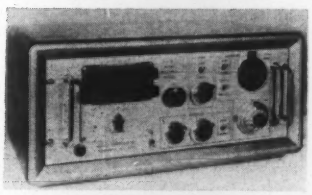
LIQUID LEVEL CONTROLLER



New Cryolevel for automatic liquid level control in liquid helium, liquid hydrogen, liquid nitrogen, and other cryogenic liquids; maintains level within a preset range from ± ¼" to 6", uses adjustable dual-element probe which returns signal to thyratron circuit that can actuate either solenoid valve or relay.—*Cryotronics, Inc., Subs. of Malaker Labs., Inc., Mountainside, N. J.*

CIRCLE 481 ON READER-SERVICE CARD

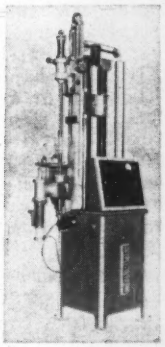
VLF BRIDGE



New transistorized VLF Mutual-inductance Bridge measures susceptibilities of paramagnetic materials at cryogenic temperatures or superconductors where frequency-dependent parameters require very low frequencies; has own power supply, signal generator, filters and built-in null-detecting oscilloscope.—*Cryotronics, Inc., Subs. of Malaker Labs. Inc., Mountainside, N. J.*

CIRCLE 482 ON READER-SERVICE CARD

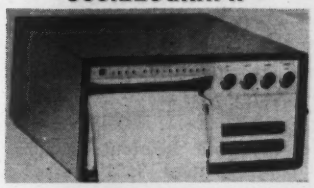
CRYSTAL GROWING FIXTURE



New Horizontal Zone Refining Attachment for floating zone and crystal pulling fixture consists of a horizontal quartz tube mounted on end-supports attached to carriage which moves quartz tube through stationary induction coil easily mounted on original basic unit containing traverse and programming mechanism.—*Lepel High Frequency Labs., Inc.,* 55 *St. & 37 Ave., Woodside* 77, *N. Y.*

CIRCLE 483 ON READER-SERVICE CARD

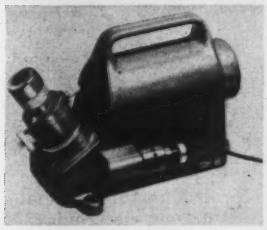
OSCILLOGRAPH



New Model 1508 Visicorder fits 24 direct-recording channels into only 7" of rack height. Each channel is capable of recording individual static or dynamic phenomena at frequencies from dc to 5000 cps with 12 speeds. Deflection of 8", peak to peak, is possible and traces are recorded at writing speeds well in excess of 50,000 ips.—*Minneapolis-Honeywell Reg. Co., Heiland Div.,* 5200 *E. Evans Ave., Denver* 22, *Colo.*

CIRCLE 484 ON READER-SERVICE CARD

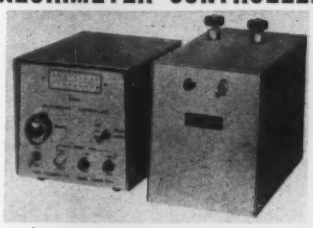
BIAXIAL AUTO-COLLIMATOR



New Leitz Auto-Collimator features diagonal direction of the minute scale in the ocular, which in itself consists of a series of angle patterns, thus furnishing readings in both coordinates, without rotating the ocular or the telescope tube, respectively.—*Opto-Metric Tools, Inc.,* 139 *Varick St., New York* 13, *N. Y.*

CIRCLE 485 ON READER-SERVICE CARD

CALORIMETER CONTROLLER



New thermistor-actuated Automatic Controller for adjusting jacket temperatures in adiabatic bomb calorimeters can be used with either old or new Parr adiabatic calorimeters. Bulletin Spec. 2600.—*Parr Instrument Co., Inc.,* 211 *Fifty-Third St., Moline, Ill.*

CIRCLE 486 ON READER-SERVICE CARD

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For fast, accurate temperature sensing from −435° to +500° F.

REC's Model 176

IMMERSION TYPE
0.2" TIME CONSTANT

Unique new design gives this temperature sensor unusually fast response. Because the precision platinum resistance element is mounted without strain directly on the inner wall of the stainless steel well, the time constant is only 0.2 second.

The Model 176 was designed for storable fuel applications in the missile field. However, it is suitable for use in any part of the −435° to +500° F. temperature range and in any fluid compatible with the stainless steel material of the well. Available in a wide range of lengths, fittings and connectors.

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Total temperature
Pitot-static (de-iced)
Immersion temperature sensors (including cryogenic)
Surface temperature sensors
Pressure transducers
Accessory equipment
Aeronautical research

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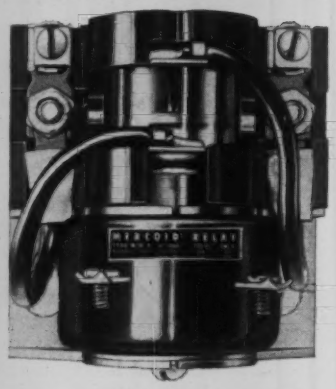
CIRCLE 153 ON READER-SERVICE CARD

35 AMP

Plunger Type

MERCOID MERCURY RELAY



If you need reliability and durability, this quality built relay by Mercoid is your answer.
For heavy duty loads, such as resistance heating, (domestic, commercial, industrial)—heat treating furnaces, drying equipment, welding, lighting, illuminated signs, score boards.
Hermetically sealed mercury to mercury contact provides visible on-off operation. Silent and chatterless. Quickly mounted, easily wired. Speeds up to 100 operations per minute.

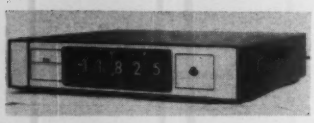
CONTACT RATING				
LOAD			NON INDUCTIVE HEATER LOADS	
	AC	DC	AC ONLY	
120V.	30A.	15A.	120V.	35A.
240V.	20A.	10A.	240V.	25A.
440V.	8A.	—	440V.	10A.

WRITE FOR BULLETIN 0-20

THE MERCOID CORPORATION,
4209 Belmont Ave.,
Chicago 41, Ill.

CIRCLE 154 ON READER-SERVICE CARD

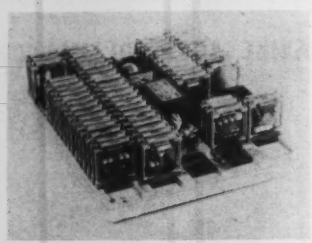
REMOTE READOUT



New Remote Readout accepts binary-coded-decimal 8421, gives decimal visual readout, and supplies binary-coded-decimal and decimal data outputs. Uses standard output level, has built-in 110-v power supply generator. Can be used with any voltmeter that supplies binary-coded-decimal 8421; available for other codes, such as 4221.—*Electronic Associates, Inc., Long Branch, N. J.*

CIRCLE 487 ON READER-SERVICE CARD

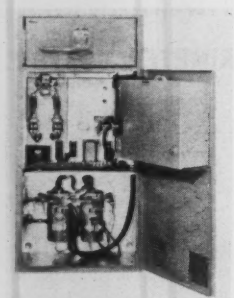
CHECKOUT INSTRUMENT



New programmable special-design high-speed pre-set electronic Counter/Timer made for Nortronics Div. of Northrup Corp. for the TRADE Polaris checkout system is now available.—*Erie-Pacific, Div. Erie Resistor Corp., Hawthorn, Calif.*

CIRCLE 488 ON READER-SERVICE CARD

WELDER CONTROL



New Norpak transistorized Resistance Welder Control features static cycle counter circuits, regulated filtered power supply; with static heat control, delayed firing, slope control and other standard control functions optional.—*Square D. Co., Export Department, 425 County Ave., Secaucus, N. J.*

CIRCLE 489 ON READER-SERVICE CARD

POLARIZING OPTICS

New manufacturing facility for crystaline $CaCO_3$ (calcite) optics permits production of polarozing prisms with volume to 18 cu in.—*Perkin-Elmer Corp., Norwalk, Conn.*

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Ultra-fast Optics

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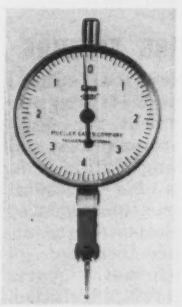
CIRCLE 155 ON READER-SERVICE CARD

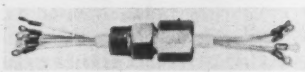
TEST INDICATORS



New 2" Test Dial Indicators feature ball bearings, no levers, geared mechanism, great sensitivity, repeatability within 0.00002" after 1 million-cycle life test. Ranges are 0.001", 0.0005" 0.0001". — *Mueller Gages Co., 1052-58 North Allen Ave., Pasadena, Calif.*

CIRCLE 491 ON READER-SERVICE CARD

LEAD SEALERS



New line of Electrical Lead Sealing Devices accepts two, four, six, or eight wires, incorporates a one-piece, single- or multiple-hole ceramic insulator contained in stainless-steel gland. By tightening cap, assembly is sealed for pressures of up to 5,000 psi. Temperature range is —40° to 450° F.—*Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.*

CIRCLE 492 ON READER-SERVICE CARD

WORLD'S MOST ACCURATE AIR PRESSURE REGULATOR

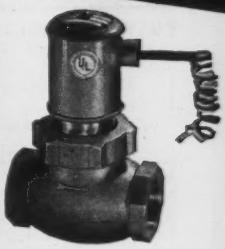
● MAINTAINS PRESSURE TO 1/5 OF 1/10 OF 1% OVER RANGE OF SUPPLY PRESSURE, FLOW, AMBIENT TEMPERATURES.

The exclusive use of *regulated air pressure* instead of supply pressure is the secret of unmatched performance.
Constant reliability results from stainless steel pressure capsule which assures stable movement under all ambient temperatures.
Three pressure ranges: 2-25; 3-60; 3-125 and NPT pipe sizes ⅛", ¼" and ⅜". Write for bulletin or send purchase order.
Unconditionally guaranteed to perform in accordance with above curve for Lexington Regulator type 10. *(Protected by U.S. and foreign patents)*
Price: $20.00 plus postage with quantity discounts.

Lexington Controls
INCORPORATED
45 Blanchard Road, Burlington, Mass.

CIRCLE 156 ON READER-SERVICE CARD

Now . . . 7 Sizes of Gould Solenoid Valves bear this seal



They're Types Q and Q-1 in all these sizes:
⅜" • ½" • ¾" • 1" • 1¼" • 1½" • 2"

Fully Automatic • Normally Closed • Packless
2-Way • Piston-Pilot Operated • Bronze Body

TYPE Q General purpose for air and water at pressures from 5 to 400 psi; temperatures to 250° F. . . . and steam at pressures to 15 psi; temperatures to 250° F.

TYPE Q-1 For steam at pressures from 5 to 150 psi, and temperatures to 365° F.

Coils of both types are guaranteed unconditionally for a full year

Write for FREE Bulletin on Our Full Line of Solenoid Valves!

TYPICAL USER NET PRICES • F.O.B. FACTORY

SIZE	TYPE Q		TYPE Q-1	
	1 to 5	100 to 499	1 to 5	100 to 499
⅜" or ½"	22.00	19.25	29.10	25.46
¾"	26.00	22.75	33.10	28.96
1"	35.00	30.63	42.10	36.84
1¼"	43.00	37.63	50.10	43.48
1½"	66.00	57.75	73.10	63.96
2"	84.00	73.50	91.10	79.71

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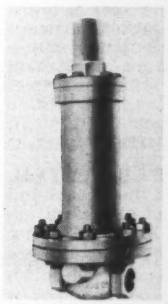
CIRCLE 157 ON READER-SERVICE CARD

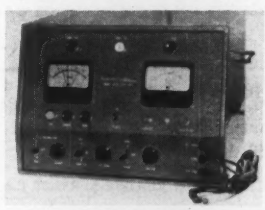
RELIEF VALVE



New 1910R, Type E single-seated spring-loaded diaphragm-actuated Relief Valve has cast-iron body with nickel-alloy or stainless-steel trim. Features include renewable valve disc and "O" ring construction, no stuffing boxes. Relief pressure ranges are: 5-55, 20-70, 35-90, and 100-250 psi. Available in six sizes from ½" to 2".—*Atlas Valve Co., 280 South St., Newark, N. J.*

CIRCLE 493 ON READER-SERVICE CARD

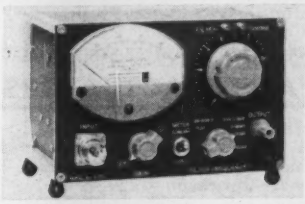
ELECTRICAL TEST SET



New Model 8522 Test Set determines high-voltage breakdown from 0 to 2.5 kv ac; continuity and ohms resistance, indicated on direct reading scales of 0-50 and 0-500 ohms; readout by signal lights.—*Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.*

CIRCLE 494 ON READER-SERVICE CARD

AMPLIFIER-NULL DETECTOR



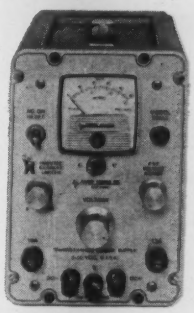
New Type 1323-A transistor Tuned Amplifier and Null Detector provides continuous tuning from 20 cps to 20 kc by RC null circuit, features low-noise 1-μv full-scale sensitivity, gain of about 40 db and another 40 db by an amplifier compressor.—*General Radio Co., West Concord, Mass.*

CIRCLE 495 ON READER-SERVICE CARD

COPPER CLAD MICARTA

New grades of Micarta Copper Clad Laminates for printed circuits include two paper-base phenolic grades with high fire resistance and one for electrically critical applications, also glass-base epoxy grades. Bulletin B8215.—*Westinghouse Electric Corp., Micarta Div., Hampton, S. C.*

CIRCLE 496 ON READER-SERVICE CARD



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MODEL 5015A

SEMICONDUCTORIZED
POWER SUPPLY
0-50 V.D.C. • 0-1.5 AMP

*Silicon. Small-Signal Transistor Amplifier with Planar Diffused Junction Input Stage

High stability solid state DC power supply with adjustable current limiting, .05% regulation, 500 μv ripple, .01 Ω source impedance, 50 μs response time, .01 volts drift/24 hours, 55-440~ input.

$234.50 F.O.B. FACTORY

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Write For Complete Catalog

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1700 SHAMES DRIVE
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BREAKTHROUGH
IN THE STATE
OF THE ART . . .

AC VOLTAGE STANDARD

0.035% ABSOLUTE ACCURACY
0.015% TOTAL DISTORTION
0-511.110 VOLTS
MILLIVOLT RESOLUTION

- MIL-SPEC DESIGN
- ALL TRANSISTORIZED

Because of its cycle-to-cycle stability and low distortion, the Rotek AC Standard, Model 146A, is the only means of calibrating high speed voltmeters. Never before has there been an AC Voltage Standard having the Rotek accuracy and reliability. Mil-spec design permits production line use with unskilled operators to Standard Laboratory accuracy.

Please write for Bulletin 146A

Other Rotek instruments:
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DC Current Standards
System References

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CIRCLE 159 ON READER-SERVICE CARD

I&CS NEW LITERATURE

CONTROL SYSTEMS

PULP CONTROL. 2-page Process Application Sheet 4-5 describes brownstock washer control.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.
CIRCLE 497 ON READER-SERVICE CARD

ENGINE MIXTURE CONTROL. 2-page Performance Report E16-1 describes application of engine-mixture control system at Panhandle Eastern Pipe Line Co.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.
CIRCLE 498 ON READER-SERVICE CARD

DISTILLATION COLUMN CONTROL. 8-page Application Bulletin 91-45-01 outlines typical practices for control of distillation columns in the chemical process industries.—Fischer & Porter Co., 6 Jacksonville Rd., Warminster, Pa.
CIRCLE 499 ON READER-SERVICE CARD

FILTER PLANT CONTROL. 8-page Bulletin 90-49-16 describes cascade control instrumentation for a typical water filter plant.—Fischer & Porter Co., 6 Jacksonville Rd., Warminster, Pa.
CIRCLE 500 ON READER-SERVICE CARD

PROCESS CONTROL CENTER. 4-page Bulletin 239.12A describes unified process control center combining readout and control functions with 4" strip-chart recorder in single panel assembly.—Republic Flow Meters Co., Subs. of Rockwell Mfg. Co., 2240 Diversey Pkwy., Chicago 47, Ill.
CIRCLE 501 ON READER-SERVICE CARD

MINI ELECTRONIC CONTROLLER. 2-page Spec Sheet 53E/53EL2000 illustrates and specifies Model 53EL-2000-Series Ratographic miniature electronic controller.—Fischer & Porter Co., Warminster, Pa.
CIRCLE 502 ON READER-SERIVCE CARD

VALVES, ACTUATORS

DRAIN OR SAMPLING VALVE. 2-page Data Unit 400 details special valves for high temperature or corrosive conditions.—Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.
CIRCLE 503 ON READER-SERVICE CARD

HI VACUUM VALVE. 8-page Booklet 328 describes three-way valve for high-vacuum systems.—Central Scientific Co. Div. Cenco Instruments Corp., 1700 W. Irving Park Rd., Chicago 13, Ill.
CIRCLE 504 ON READER-SERVICE CARD

ELECTROHYDRAULIC ACTUATOR 2-page Bulletin H-33 describes features and installations of dual springless Hydramotor® actuator.—General Controls Co., Industrial Controls Div., 801 Allen Ave., Glendale, Calif.
CIRCLE 505 ON READER-SERVICE CARD

HAND AND CHECK VALVES. 24-page Catalog Form 232-11-60 describes bronze, iron, steel and specially globe, angle, gate, check valves, etc.—Wm. Powell Co., 2503-31 Spring Grove Ave., Cincinnati 22, Ohio.
CIRCLE 506 ON READER-SERVICE CARD

BALL VALVES. 32-page Catalog 1200-A details complete line of manually-operated and pneumatically-operated ball valves.—Hill-McCanna Co., 400 Maple Ave., Carpentersville, Ill.
CIRCLE 507 ON READER-SERVICE CARD

SLIDING GATE CONTROL VALVES. 8-page Catalog DCV-1 describes sliding-gate-seat control valves that provide tight shut-off and accurate control.—OPW-Jordan, 6013 Wiehe Rd., Cincinnati 37, Ohio.
CIRCLE 508 ON READER-SERVICE CARD

PRESSURE, VACUUM FORCE, ACCELERATION

ABS PRESS TRANSDUCER. 2-page Bulletin 2521/H/1 describes with specs and dimensional sketch Model 2521 diaphragm/strain gage type transducer.—Bourns, Inc., Instrument Div., 6135 Magnolia Ave., Riverside, Calif.
CIRCLE 509 ON READER-SERVICE CARD

SOLID STATE ACCELEROMETER. 2-page flyer announces Model AH1L solid-state accelerometer with 5-volt output.—Data Sensors, Inc., 13112 Crenshaw Blvd., Gardena, Calif.
CIRCLE 510 ON READER-SERVICE CARD

LOAD CELLS. 8-page Gen. Catalog 100 describes dynamometers, scales, physical testing machines and new load cell system.—W. C. Dillon & Co. Inc., 14620 Keswick St., Van Nuys, Calif.
CIRCLE 511 ON READER-SERVICE CARD

PRESSURE SENSING. 2-page Bulletin P-61185-290 presents new Model 185/290-2 airborne pressure transducer.—Taber Instrument Corp., North Tonawanda, N. Y.
CIRCLE 512 ON READER-SERVICE CARD

VACUUM EQUIPMENT. 22-page catalog and price list feature special high-vacuum systems, gold-jacket furnaces (to 2500°C), custom-designed pump stations and evaporators, ionization gage controls and stainless steel valves.—F. J. Cooke Inc., 145 Water St., South Norwalk, Conn.
CIRCLE 513 ON READER-SERVICE CARD

PRESS, TORQUE, LOAD SYSTEM. 2-page Data Sheet 4402 illustrates and describes low-cost direct amplification system for indicating and controlling pressure, torque and load.—Hamilton Corp., 42 Fourth Ave., Waltham 54, Mass.
CIRCLE 514 ON READER-SERVICE CARD

MILTI-POINT GAGES. 4-page Bulletin 322.11 describes line of multi-point gages for indicating draft, pressure, differential, and temperature.—Republic Flow Meters Co., Subs. of Rockwell Mfg. Co., 2240 Diversey Pkwy., Chicago 47, Ill.
CIRCLE 515 ON READER-SERVICE CARD

TEMPERATURE

PLASTIC T/C. 4-page Bulletin TB161 gives details of Model P Thermocouple for plastics, non-metals, alloys, etc.—Nanmac Corp., Box 8, Indian Head, Md.
CIRCLE 516 ON READER-SERVICE CARD

TEMP TRANSDUCERS. 4-page Special Product Note 2342 discusses Tanatherm interchangeable surface temperature transducers.—Trans-Sonics, Inc., Box 328, Lexington 73, Mass.
CIRCLE 517 ON READER-SERVICE CARD

OGP "ETCH-PRINT"
ADDS NEW PERMANENCE, VARIETY AND ECONOMY

to Your Control Consoles and Instrument Panels . . .

OGP's new "Etch-Print" impregnates legends, scales, monograms and other data directly into the surface of Thermo-plastic materials, providing a "new look" in control panel fronts.

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CIRCLE 160 ON READER-SERVICE CARD

PRESSURE TRANSDUCER. 2-page Bulleting 4328 describes capabilities of Type 4-328 shunt-compensated pressure transducer.—Transducer Div., Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 518 ON READER-SERVICE CARD

PRESSURE TRANSMITTERS. 2-page Bulletin R-4 describes new Compu-Tran explosion-proof, low-pressure cell for pressure measurement applications.—International Resistance Co., 601 N. Broad St., Phila. 8, Pa.

CIRCLE 519 ON READER-SERVICE CARD

PRESSURE MEASUREMENT. 4-page Bulletin describes new instrument which may be used with a high degree of accuracy as a low pressure deadweight gage or a high range differential pressure manometer. Uses "principle of operation not heretofore employed." Standard and dual scales may be read to 0.1" WC. or 0.01 psi, with full scale of 1000" WC or 36 psi. —ToPaz, Inc., 2525 South Blvd., Houston 6, Tex.

CIRCLE 520 ON READER-SERVICE CARD

GAGES. 12-page Bulletin 321.11 describes compact, easy-to-read V5 gages for indicating draft, pressure, differential gas pressure and temperature and pneumatic impulses from transmitters.—Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.

CIRCLE 521 ON READER-SERVICE CARD

PRESSURE-SENSITIVE TAPES—masking, protective, electrical, printable, etc.—are described in 44-page booklet. —Mystik Adhesive Products, Inc., 2635 No. Kildare Ave., Chicago 39, Ill.

CIRCLE 522 ON READER-SERVICE CARD

WEIGHING. 8-page Form 2968a describes automatic in-line Checkweighers which feature "zone-edge tolerance."—Toledo Scale, Div. Toledo Scale Corp., Toledo 12, Ohio.

CIRCLE 523 ON READER-SERVICE CARD

LIVE BIN FEEDER. 4-page bulletin provides details on Live Bin Feeder for metering dry materials.—Vibra Screw Feeders, Inc., 156 Huron Ave., Clifton, N. J.

CIRCLE 524 ON READER-SERVICE CARD

TABLE FEEDER. 4-page Bulletin 23-02.20-1 illustrates and describes self-contained, portable Table Feeder for dry materials, Model 23-02.—B-I-F Industries, Box 276, Providence, R. I.

CIRCLE 525 ON READER-SERVICE CARD

PNEUMATIC TOTALIZER. 2-page Spec Sheet 282-09.201-1 describes with dimensional sketch self contained panel mounted Pneumatic Totalizer Model 282-09.—B-I-F Industries, Box 276, Providence, R. I.

CIRCLE 526 ON READER-SERVICE CARD

STREAM BLENDING SYSTEMS. 4-page Bulletin 2000.20-1 details many of the advantages and improved techniques of blending, both for refining and pipelining as well as marketing.—B-I-F Industries, Box 276, Providence, R. I.

CIRCLE 527 ON READER-SERVICE CARD

GAS CHROMATOGRAPHY. 2-page Data Sheet E-ND46(9) describes Speedomax G & H recorders for laboratory gas chromatography applications.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

CIRCLE 528 ON READER-SERVICE CARD

DC POWER SUPPLY. 2-page bulletin describes d-c power supply for solid-state computers.—Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.

CIECLE 529 ON READER-SERVICE CARD

HI-TENSION SEPARATOR. 2-page Bulletin HPB114 describes high-tension separator for research use.—Carpco Research and Engineering, Inc., Jacksonville 6, Fla.

CIRCLE 530 ON READER-SERVICE CARD

RESISTANCE OF ACID-PROOF CEMENTS. 6-page Bulletin No. 1 contains a list of more than 75 corrodent solutions and a rating for various types of acid-proof cements.—Acid-Proof Cement Mfrg. Assoc., 1015 Chestnut St., Phila. 7, Pa.

CIRCLE 531 ON READER-SERVICE CARD

ALLOY. 8-page Bulletin 112 describes Hoskins Alloy 750 special low-growth iron-chromium-aluminum resistance material for heating elements in small appliances where operating temps do not exceed 2050°F.—Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.

CIRCLE 532 ON READER-SERVICE CARD

MASS SPECTROMETER. 6-page Bulletin 21130 describes Type 21-130 cycloidal focusing Mass Spectrometer utilizing cycloid tube with 1.1" focal distance and permanent magnet charged to approximately 4500 gauss. —Consolidated Electrodynamics Corp., Subs. Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif.

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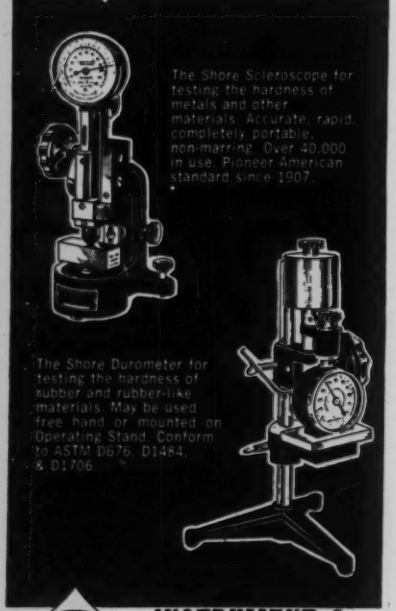
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THERMOCOUPLE WIRE. 12-page Bulletin 1-100 describes SERV-RITE insulated thermocouple wire, thermocouple extension wire, and extension cable.—Claud S. Gordon, Co., 3000 S. Wallace St., Chicago 16, Ill.

CIRCLE 534 ON READER-SERVICE CARD

FLOW, PUMPS, LEVEL

METERING PUMP. 2-page Bulletin 794 describes with specs solution-metering pump.—Beckman Instruments, Inc., Scientific and Process Instruments Div., 2500 Harbor Blvd., Fullerton, Calif.

CIRCLE 535 ON READER-SERVICE CARD

SOLID-STATE FLOW TRANSMITTER. 2-page Bulletin 18-E describes Model S-All-Tronic rotameter transmitter.—Schutte and Koerting Co., Instrument Div., Cornwells Heights, Bucks Co., Pa.

CIRCLE 536 ON READER-SERVICE CARD

LEVEL CONTROLLER. 10-page Bulletin XE-101 describes components and operation principle of Delta C detector in electronic liquid-level sensor system. Includes dimensional sketches.—Trimount Instrument Div. General Controls Co., 8080 McCormick Blvd., Skokie, Ill.

CIRCLE 537 ON READER-SERVICE CARD

VENTURI FLOW NOZZLE. 2-page specification Data 134.201-1 contains descriptive material, dimensions and capacity tables of Model 134.—B-I-F Industries, Box 276, Providence 1, R. I.

CIRCLE 538 ON READER-SERVICE CARD

IN-LINE BLENDING. 4-page Data Sheet SY-2 describes digital and analog blending systems.—Aeronautical Corp., U. S. Route #22, Union, N. J.

CIRCLE 539 ON READER-SERVICE CARD

HI-VAC PUMPS AND COMPONENTS. 6-page Booklet 2 details Cenco series of two-stage Hyvac vacuum pumps.—Central Scientific Co. Div. Cenco Instruments Corp., 1700 W. Irving Park Rd., Chicago 13, Ill.

CIRCLE 540 ON READER-SERVICE CARD

ELECTRONIC TRANSMITTER. 2-page Spec Sheet 50E/1101 illustrates and specifies 1100-Series two-wire electronic transmitter.—Fischer & Porter Co., Warminster, Pa.

CIRCLE 541 ON READER-SERVICE CARD

MAGNETIC FLOWMETER INDICATOR. 2-page Spec Sheet 10D2/1323 illustrates and describes Model 1323BF-Series flow rate indicator for Model 10d1400-Series magnetic flowmeters.—Fischer & Porter Co., Warminster, Pa.

CIRCLE 542 ON READER-SERVICE CARD

MINI PNEUMATIC INSTRUMENTS. Three 4-page specifications describe PneumatiK Tel-O-Set line including indicators and recorders without control (S1004-1), recording and indicating control stations (S1004-2), and recording and indicating control stations for cascade control (S1004-3).—Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Aves., Phila. 44, Pa.

CIRCLE 543 ON READER-SERVICE CARD

PNEUMATIC RECEIVER. 8-page Product Data All3.3.3-2 describes the Series 670 Metagraphic® pneumatic receiver.—Bristol Co., Waterbury 20, Conn.

CIRCLE 544 ON READER-SERVICE CARD

RECORDERS. 12-page Catalog GEA-6933A describes line of direct- and servo-operated, switchboard and portable recorders.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 545 ON READER-SERVICE CARD

X-Y RECORDERS. 6-page bulletin describes X3-606 MOdel 300 and Series 400 X-Y recorders, also Series 4700 data converter.—Electro Instruments, Inc., 3540 Aero Court, San Diego 11, Calif.

CIRCLE 546 ON READER-SERVICE CARD

DATA HANDLING

DATA SYSTEM. 16-page Bulletin 3407 describes the MicroSADIC digital data acquisition system.—Consolidated Systems Corp., 1500 S. Shamrock Ave., Monrovia, Calif.

CIRCLE 547 ON READER-SERVICE CARD

COMPUTING SYSTEM. 6-page Brochure BSP 07611 illustrates hardware, software, and service features of the G-20 computing system.—Bendix Computer Div., 5360 Arbor Vitae St., Los Angeles 45, Calif.

CIRCLE 548 ON READER-SERVICE CARD

TAPE READERS. 2-page Bulletin 761 describes and specified three modular-design block tape readers.—Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.

CIRCLE 549 ON READER-SERVICE CARD

TAPE READER. 4-page Spec Release DSD-SR describes with performance specs Model 84 punched-tape reader.—Cook Electric Co., Data-Stor Div., 8100 Monticello Ave., Skokie, Ill.

CIRCLE 550 ON READER-SERVICE CARD

TAPE READER. 2-page bulletin illustrates and describes Models TP-480 and TP-482 80-bit bi-directional punched tape reader.—Electronic Engineering Co. of Calif., Automation Div., 1601 E. Chestnut Ave., Santa Ana, Calif.

CIRCLE 551 ON READER-SERVICE CARD

INTERROGATORS. 24-page brochure describes random access file interrogators.—Information Products Corp., 156 Sixth St., Cambridge, Mass.

CIRCLE 552 ON READER-SERVICE CARD

PRINTER PEDESTALS. 4-page Brochure G861 describes recently announced Control Pedestals for Series 4-1000 high-speed line printers.—Anelex Corp., 150 Causeway St., Boston, Mass.

CIRCLE 553 ON READER-SERVICE CARD

DATA ACQUISITION SYSTEM. 4-page folder describes 10-channel analog-to-pulse duration system.—Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.

CIRCLE 554 ON READER-SERVICE CARD

TAPE PROGRAMMERS. 4-page bulletin illustrates, describes, and specifies 2 models perforated-tape programmers.—Crestmont Electronics Div. Crestmont Consolidated Corp., 2201 W. Burbank Blvd., Burbank, Calif.

CIRCLE 555 ON READER-SERVICE CARD

TELEMETRY CHECKOUT. 4-page bulletin describes and specifies Model 28-1-2 portable commutator simulator and Model 28-1 portable PAM-PDM decommutator.—Crestmont Electronics Div. Crestmont Consolidated Corp., 2201 W. Burbank Blvd., Burbank, Calif.

CIRCLE 556 ON READER-SERVICE CARD

DATA TRANSMISSION. 4-page Bulletin 50-102 specifies accumulated count data transmission system.—Datex Corp., Subs. of Giannini Controls Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 557 ON READER-SERVICE CARD

GAS FLOW MONITOR. 2-page Bulletin SD-103 describes features of gas flow recording and interruptible monitoring system.—Datex Corp., Subs. of Giannini Controls Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 558 ON READER-SERVICE CARD

TESTING

TEST INSTRUMENTS. 4-page Bulletin CC-861 is a condensed Catalog of precision VTVM, VSWR, R-F power meter, signal generators, slitted-line instruments, mini magnetic-tape recorders, data reduction systems, transducers, and accelerometers.—Borg-Warner Controls Div. Borg-Warner Corp., 3300 Newport Blvd., Santa Ana, Calif.

CIRCLE 559 ON READER-SERVICE CARD

CORONA TESTING. 4-page Bulletin 4-10.27 contains data on a new line of integrated corona test sets, corona-free high voltage testers, corona detectors, and corona pickup networks. —Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.

CIRCLE 560 ON READER-SERVICE CARD

T/C REFERENCE JUNCTIONS. 4-page folder describes three Thermo-Ref series which provides constant reference junctions of 100°, 121°, and 150°C, respectively.—Genistron, Inc., 6320 W. Arizona Circle, Los Angeles 45, Calif.

CIRCLE 561 ON READER-SERVICE CARD

SIGNAL CONDITIONER. 7-page Bulletin 101 describes line of strain-gage signal conditioning equipment.—Astra Technical Instrument Corp., 9905 W. Jefferson Blvd., Culver City, Calif.

CIRCLE 562 ON READER-SERVICE CARD

SYNCHRO AND RESOLVER TESTER. 4-page Bulletin SD-102 describes system and test procedure.—Kearfott Div., General Precision, Inc., Little Falls, N. J.

CIRCLE 563 ON READER-SERVICE CARD

PRESSURE TESTERS. 4-page catalog describes dead weight and comparator testers.—Mansfield & Green Inc., 6185 Cochran Rd., Cleveland 39, Ohio.

CIRCLE 564 ON READER-SERVICE CARD

TRANSISTOR NOISE ANALYZING. 2-page brochure describes transistor noise and dynamic measurement of it. —Quan-Tech Labs., Inc., Boonton, N. J.

CIRCLE 565 ON READER-SERVICE CARD

TENSION MEASURING. 2-page data sheet illustrates and describes meters for checking tensions in paper, plastics, and fabrics, as well as wire, cable and cord.—Testing Machines Inc., 72 Jericho Tpk., Mineola, N. Y.

CIRCLE 566 ON READER-SERVICE CARD

DYNAMOMETER TEST STATIONS. 4-page Bulletin T1150 describes dynamometer test stations for multiple evaluation of inertial gyro spin motors.—Dunn Engineering Corp., 225 O'Brien Hwy., Cambridge, Mass.

CIRCLE 567 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

FREQUENCY CONVERTER. 2-page bulletin gives description and specs of Model HLFC-120 log frequency converter.—Houston Instrument Corp., Box 22234, Houston 27, Texas.

CIRCLE 568 ON READER-SERVICE CARD

RESISTANCE STANDARDS. 4-page brochure details resistance measurement accuracy as applied to working master resistances and resistance networks.—GB Components, Inc., 14621 Arminta St., Van Nuys, Calif.

CIRCLE 569 ON READER-SERVICE CARD

ELECTRONIC INTEGRATOR. 6-page Bulletin 041 describes with diagrams electronic integrator PX592 and attenuator accessory.—Ridgefield Instrument Group Div., of Schlumberger, Box 337, Ridgefield, Conn.

CIRCLE 570 ON READER-SERVICE CARD

PICOAMMETER. 2-page Bulletin GEC-1724 describes picoammeter for nuclear applications.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 571 ON READER-SERVICE CARD

ELECTRIC INDICATORS. 4-page bulletin illustrates and specifies voltmeters and frequency meters with expanded scale, also true-rms voltmeters, r-f ammeters, and running-time meters. —Quality Electric Co., 3700 S. Broadway, Los Angeles 7, Calif.

CIRCLE 572 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC COMPONENTS

DC AMPLIFIERS. 5-page Bulletin A2606 describes and specifies 4 models of d-c amplifiers.—Electro Instruments, Inc., 3540 Aero Court, San Diego 11, Calif.

CIRCLE 573 ON READER-SERVICE CARD

DC AMPLIFIERS. 4-page Catalog 4-1 lists with specs 13 types of d-c amplifiers.—Video Instruments Co., Inc., 3002 Pennsylvania Ave., Santa Monica, Calif.

CIRCLE 574 ON READER-SERVICE CARD

DISSOLVED OXYGEN ANALYZER. 2-page Bulletin 16034D illustrates and describes Models OA-1 and OA-2.—Industrial Instruments Inc., 89 Commerce Rd., Cedar Grove, Essex Co., N. J.

CIRCLE 575 ON READER-SERVICE CARD

DISSOLVED OXYGEN ANALYZER. 5-page Cat. File 650.110 describes construction, operation and installation of Type DO-100 continuous analyzer. —Wallace & Tiernan Inc., 25 Main St., Belleville 9, N. J.

CIRCLE 576 ON READER-SERVICE CARD

ELECTRONIC COUNTER. 4-page bulletin describes electronic counter for liquid measuring systems.—Veeder-Root Inc., 70 Sargeant St., Hartford 2, Conn.

CIRCLE 577 ON READER-SERVICE CARD

INSTRUMENT COUNTERS. 16-page Catalog 400 illustrates and describes with dimensional sketches instrument counters for digital readout.—Durant Mfg. Co., 1914 N. Buffum St., Milwaukee 1, Wis.

CIRCLE 578 ON READER-SERVICE CARD

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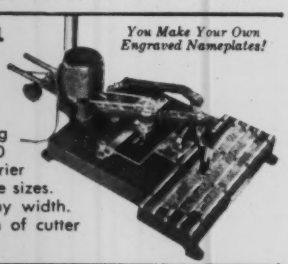

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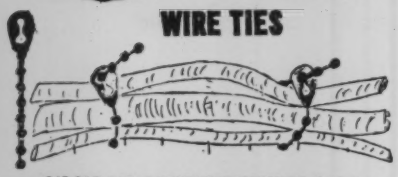

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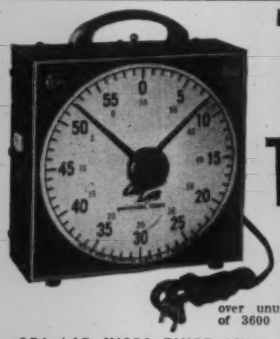

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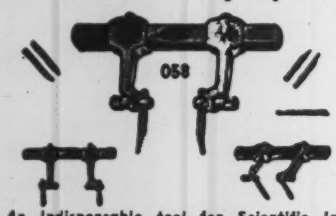

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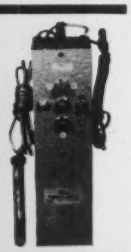

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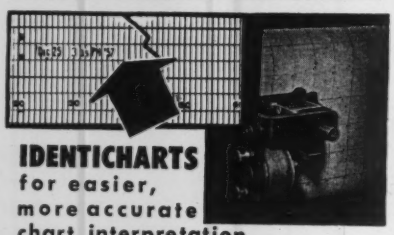

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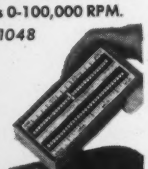

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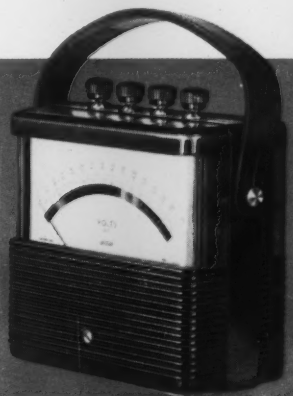

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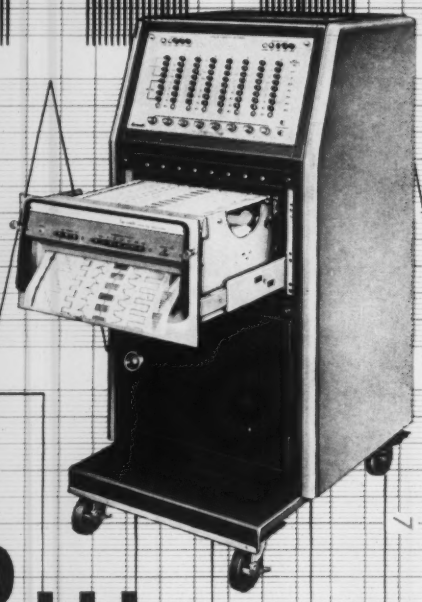

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